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(12) **United States Patent**
Newman

(10) **Patent No.: US 10,840,615 B2**
(45) **Date of Patent: Nov. 17, 2020**

(54) **CONNECTION ENCLOSURE ASSEMBLIES, CONNECTOR SYSTEMS AND METHODS FOR FORMING AN ENCLOSED CONNECTION BETWEEN CONDUCTORS**

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(72) Inventor: **John Anthony Newman**, Garner, NC (US)

(73) Assignee: **TE CONNECTIVITY CORPORATION**, Berwyn, PA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/453,513**

(22) Filed: **Jun. 26, 2019**

(65) **Prior Publication Data**

US 2020/0006869 A1 Jan. 2, 2020

Related U.S. Application Data

(60) Provisional application No. 62/691,419, filed on Jun. 28, 2018.

(51) **Int. Cl.**

H01R 4/2445 (2018.01)
H01R 4/70 (2006.01)
H01R 13/58 (2006.01)

(52) **U.S. Cl.**

CPC ***H01R 4/2445*** (2013.01); ***H01R 4/70*** (2013.01); ***H01R 13/582*** (2013.01)

(58) **Field of Classification Search**

CPC H01R 13/5215; H01R 13/521; H01R 13/582; H01R 4/2445; H01R 4/70

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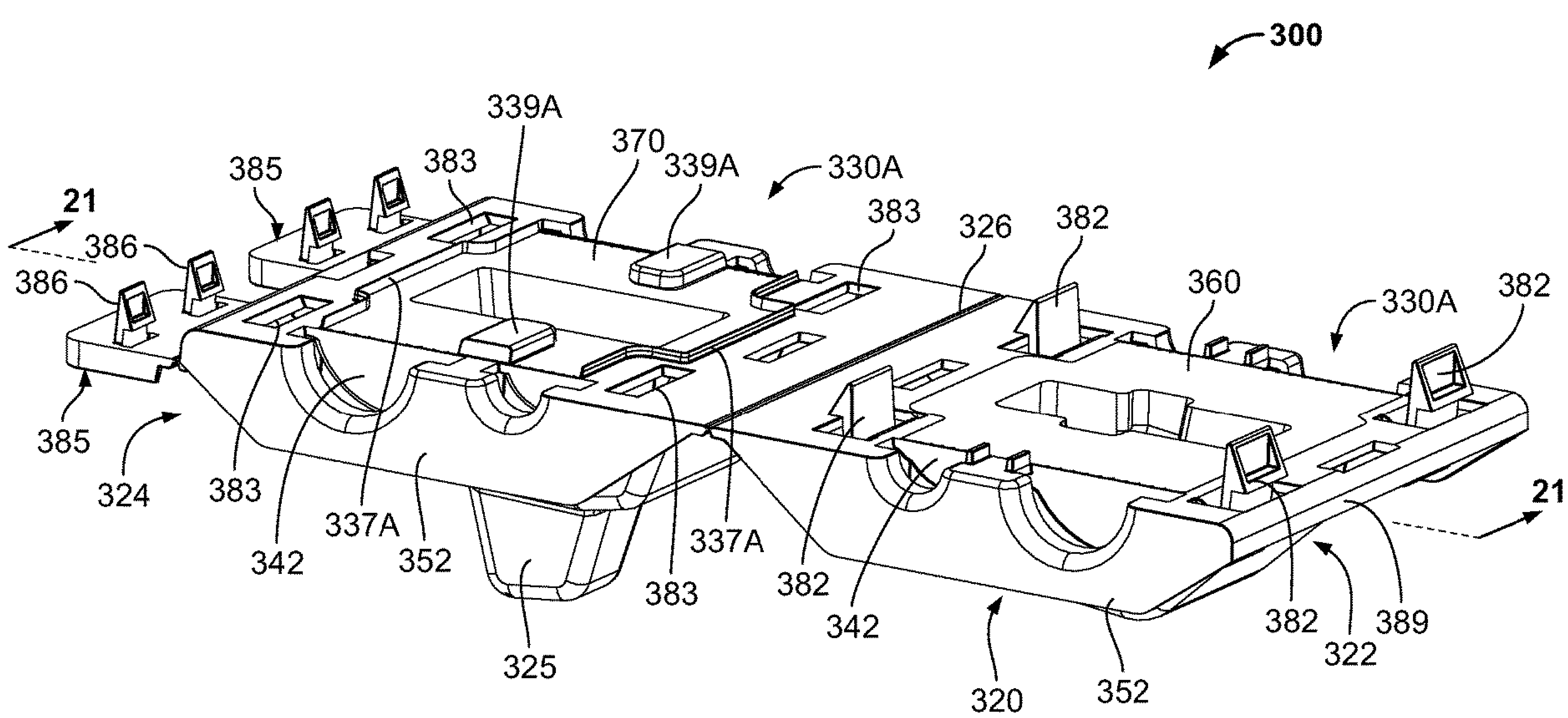
Primary Examiner — Gary F Paumen

(57) **ABSTRACT**

An enclosed connection system for mechanically and electrically connecting first and second cables, the cables each including an elongate electrical conductor covered by an insulation layer, includes an insulation piercing connector and an enclosure. The insulation piercing connector includes at least one electrically conductive piercing member and a clamping mechanism. The clamping mechanism is configured and operable to force the at least one piercing member through the insulation layers of the first and second cables and into electrical engagement with the conductors of the first and second cables such that the conductors of the first and second cables are electrically connected to one another through the at least one piercing member. The enclosure is configured to receive and cover the connection and to protect the insulation piercing connector.

18 Claims, 27 Drawing Sheets



(58) **Field of Classification Search**
USPC 439/413, 521, 936
See application file for complete search history.

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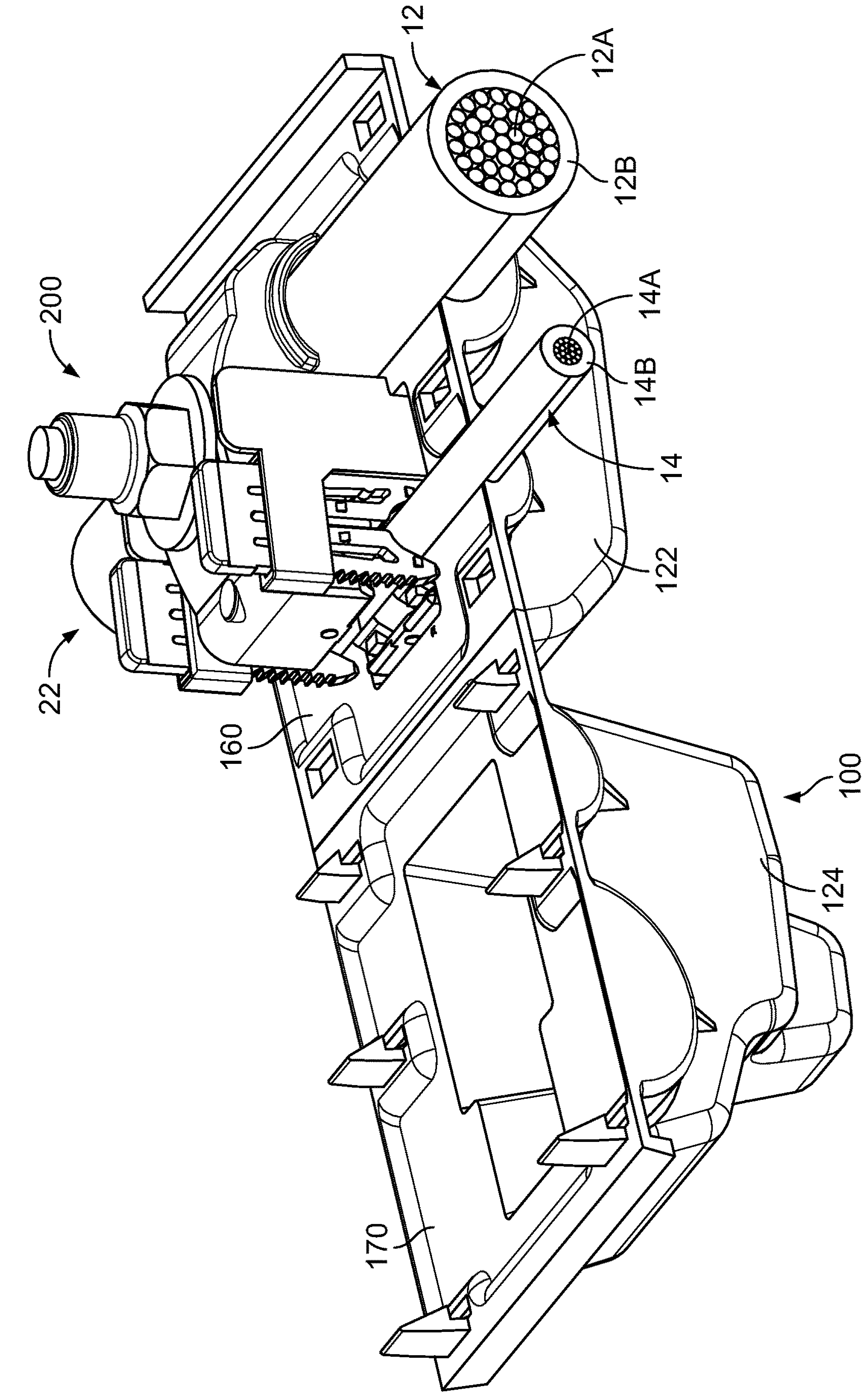


FIG. 1

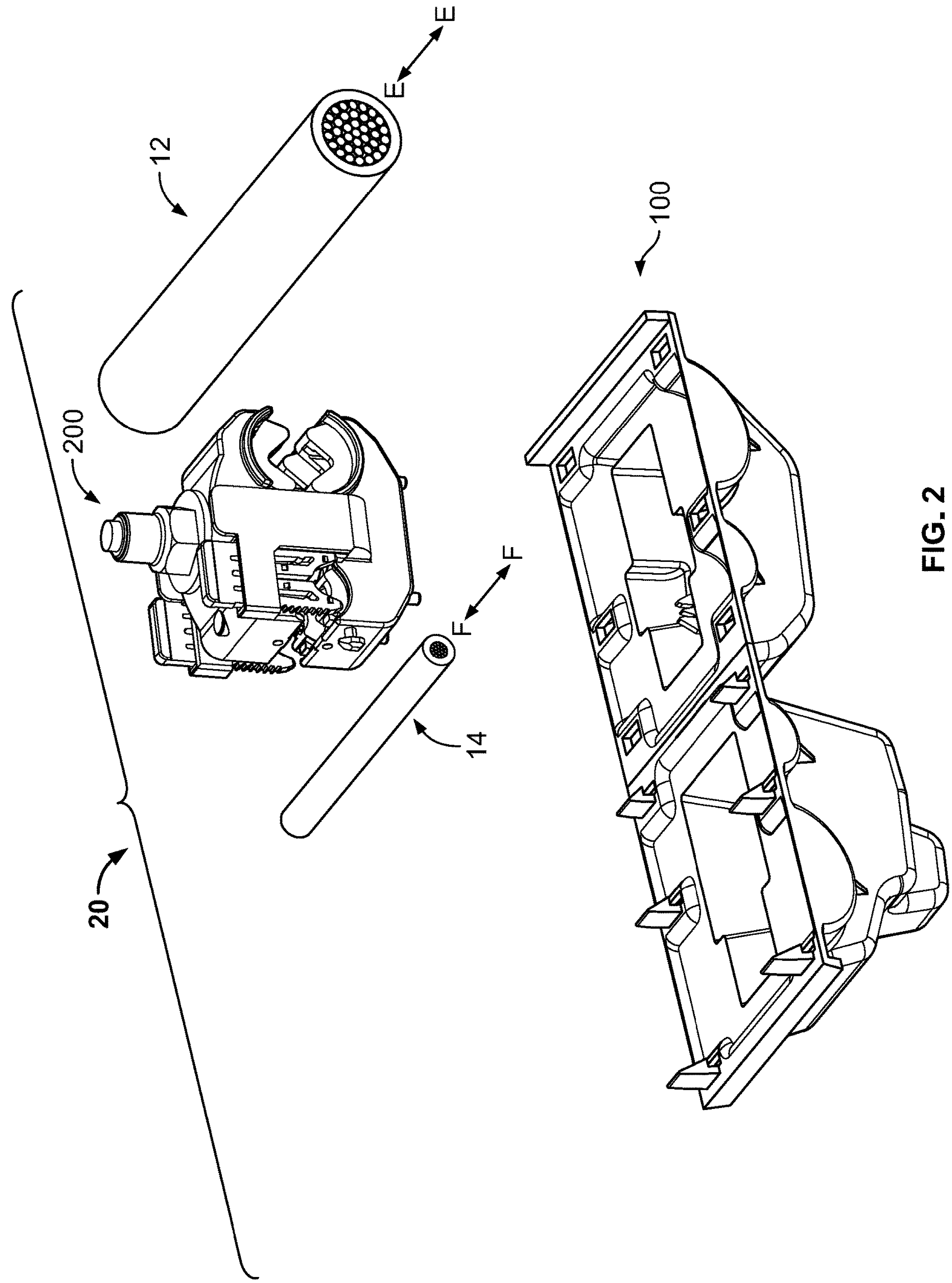
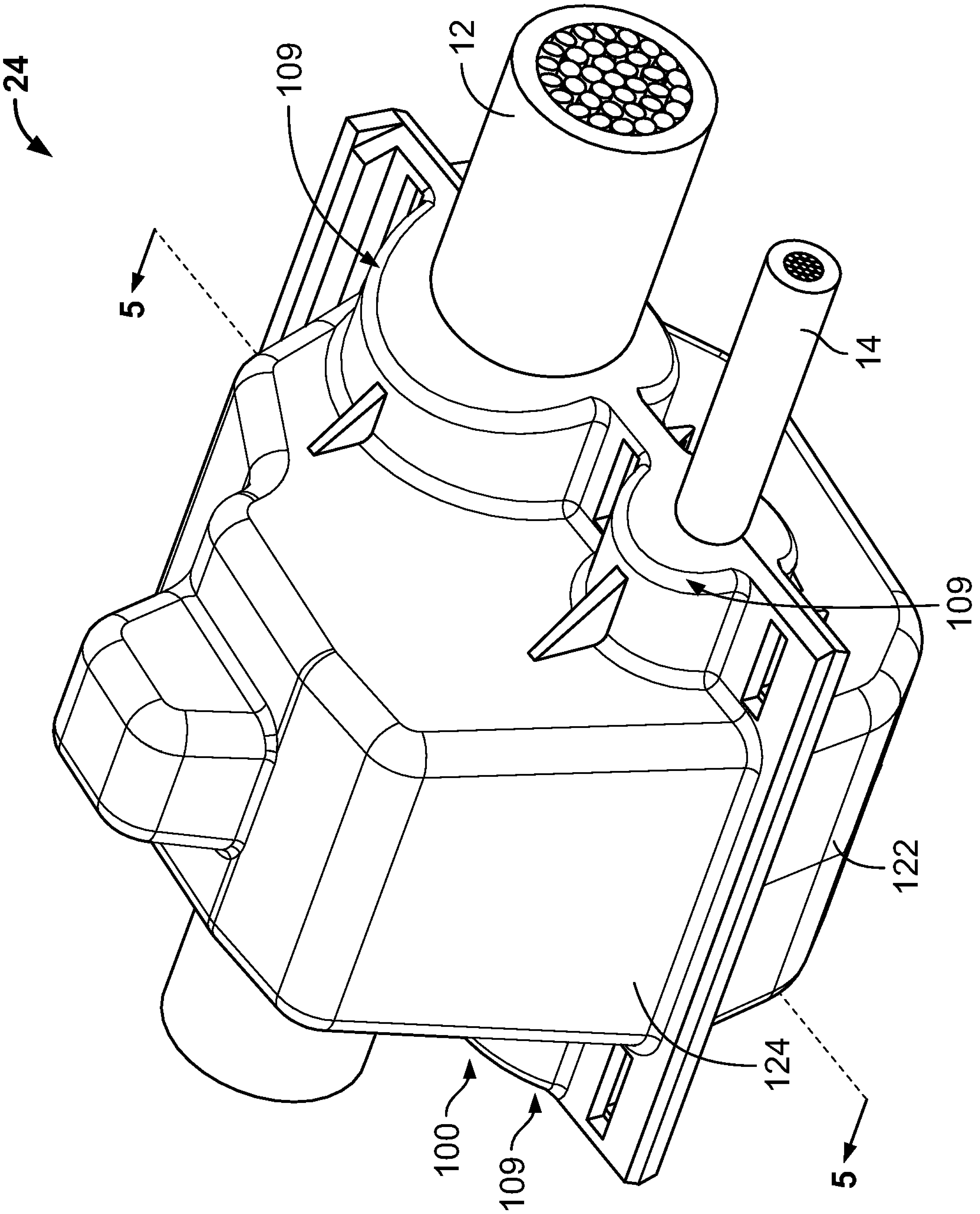


FIG. 2



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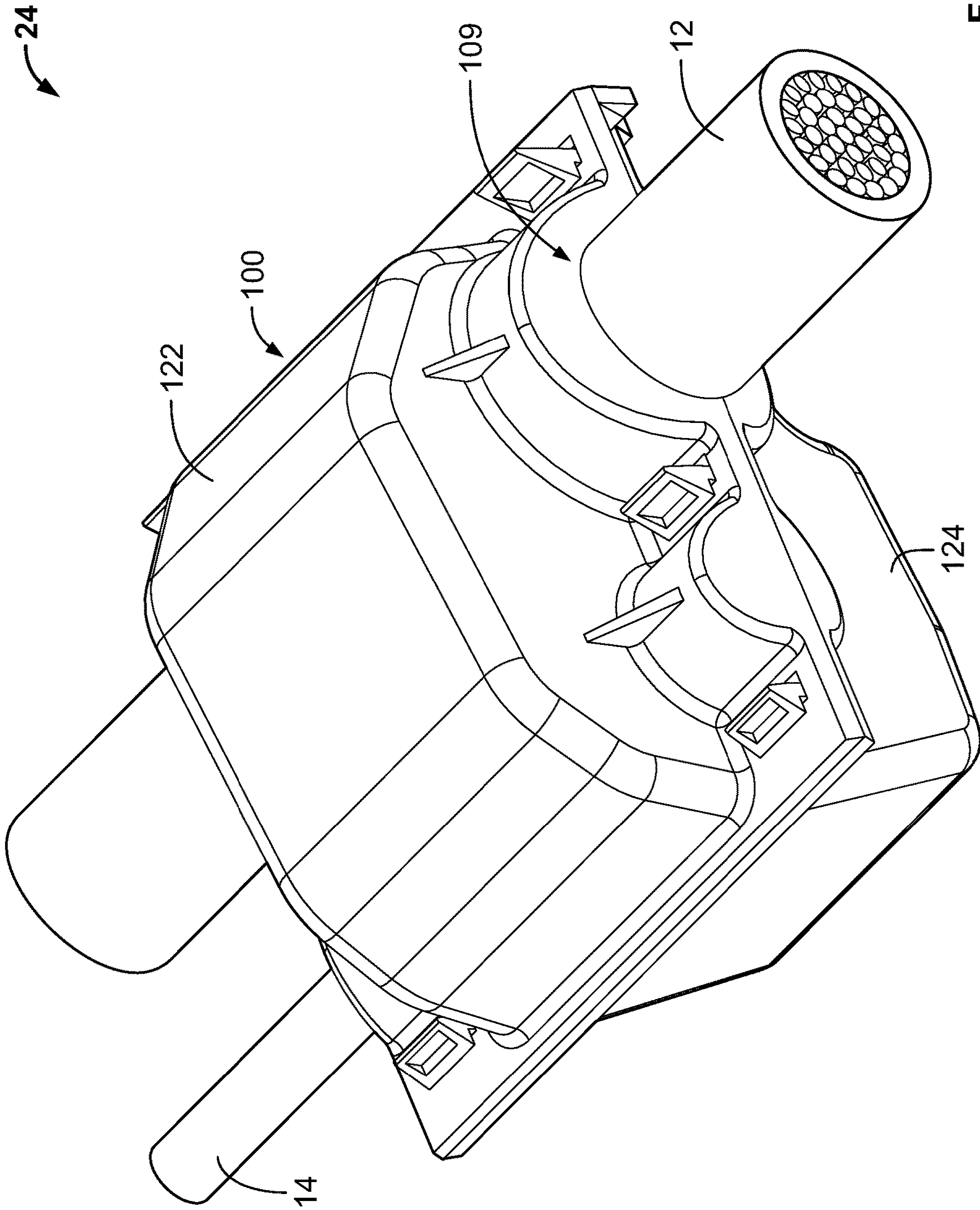

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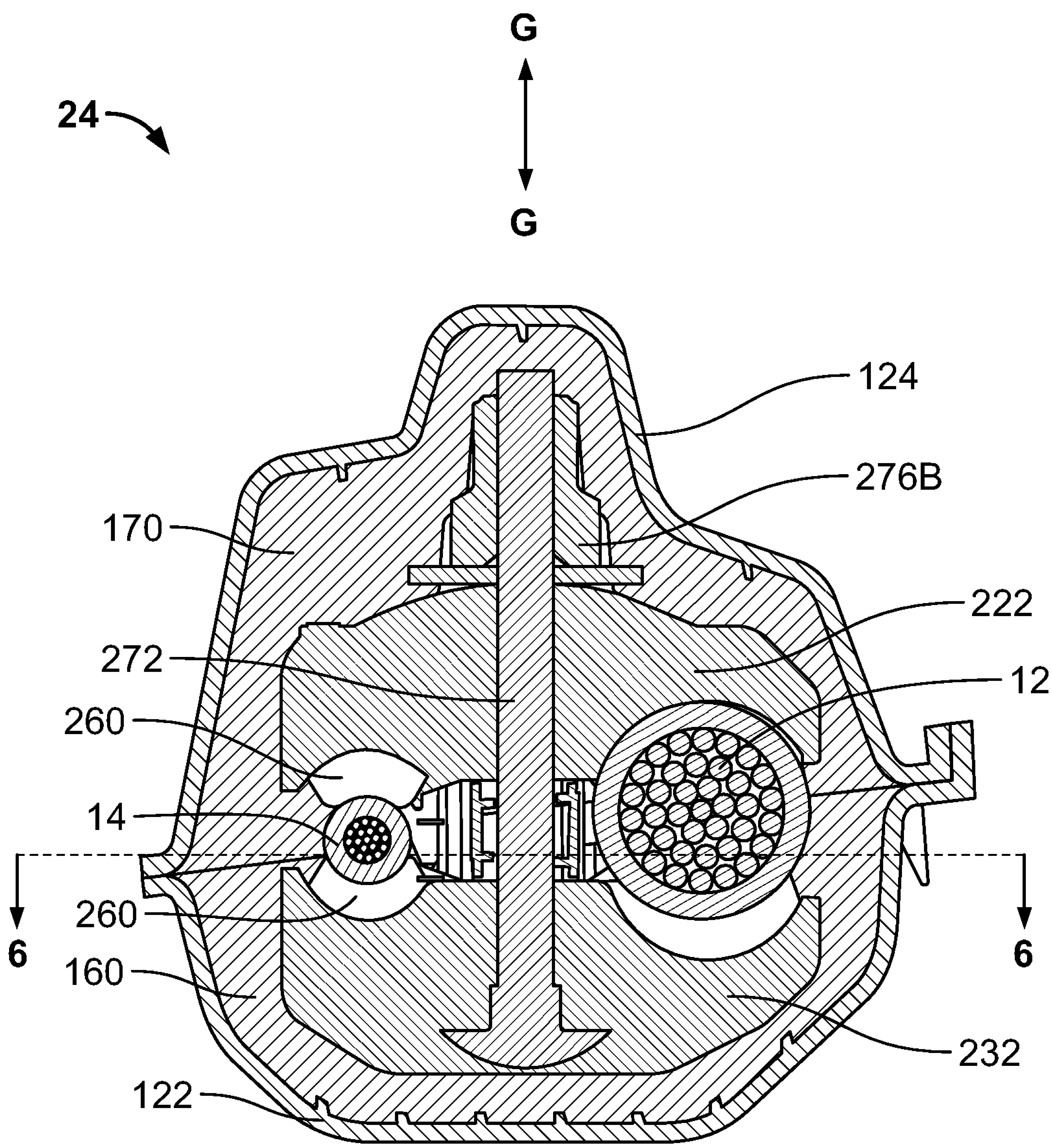

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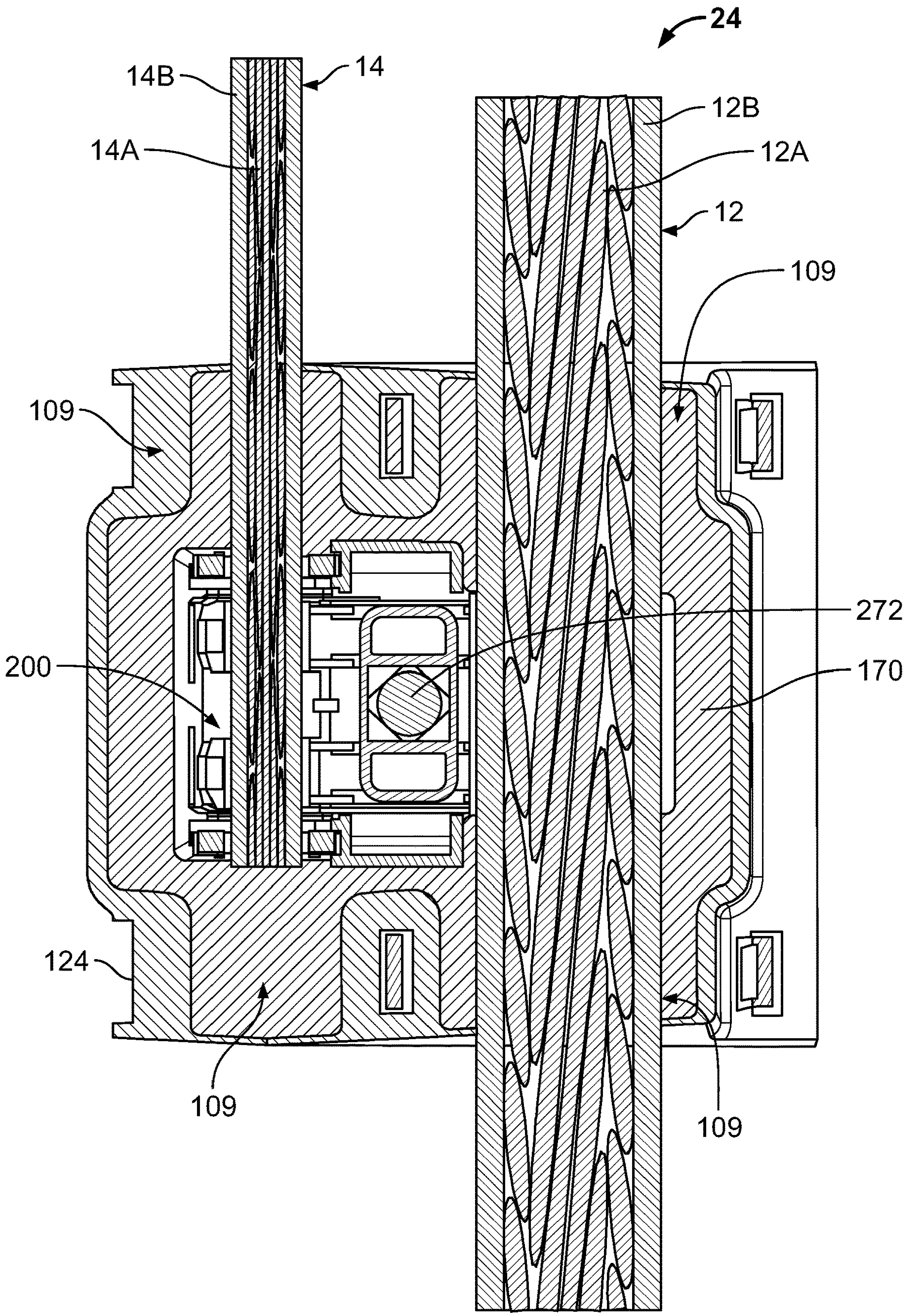

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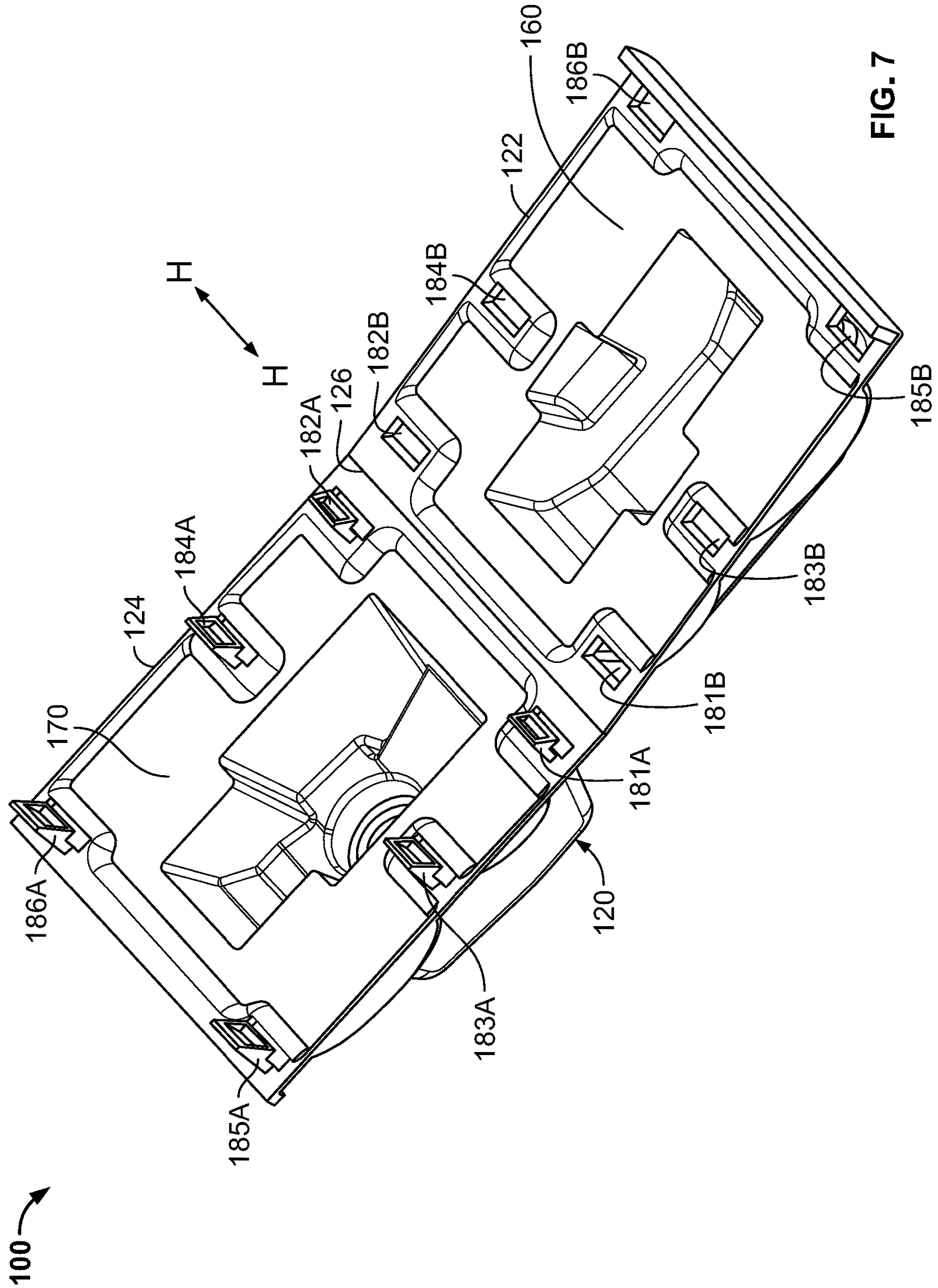
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H
H

FIG. 7

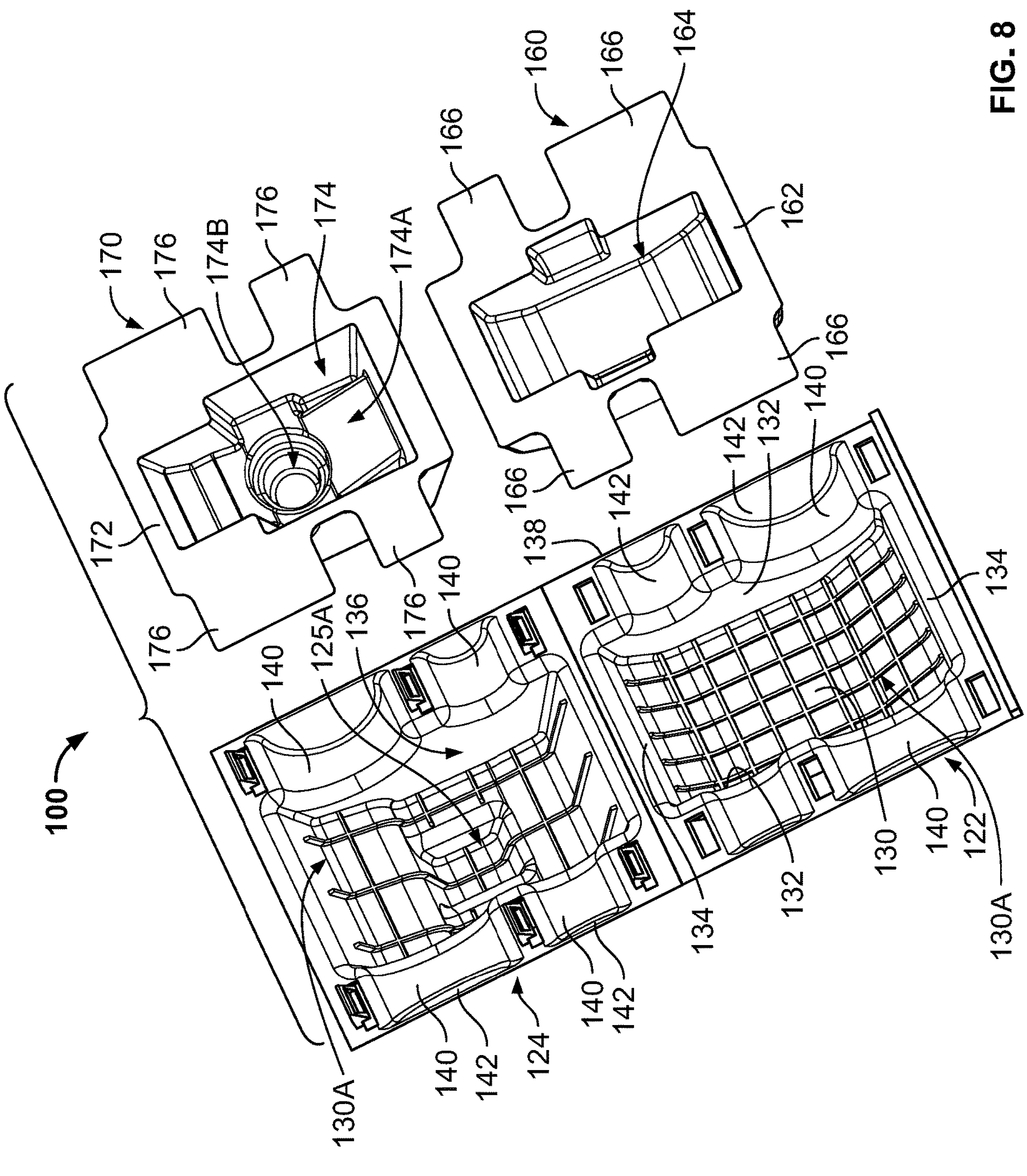
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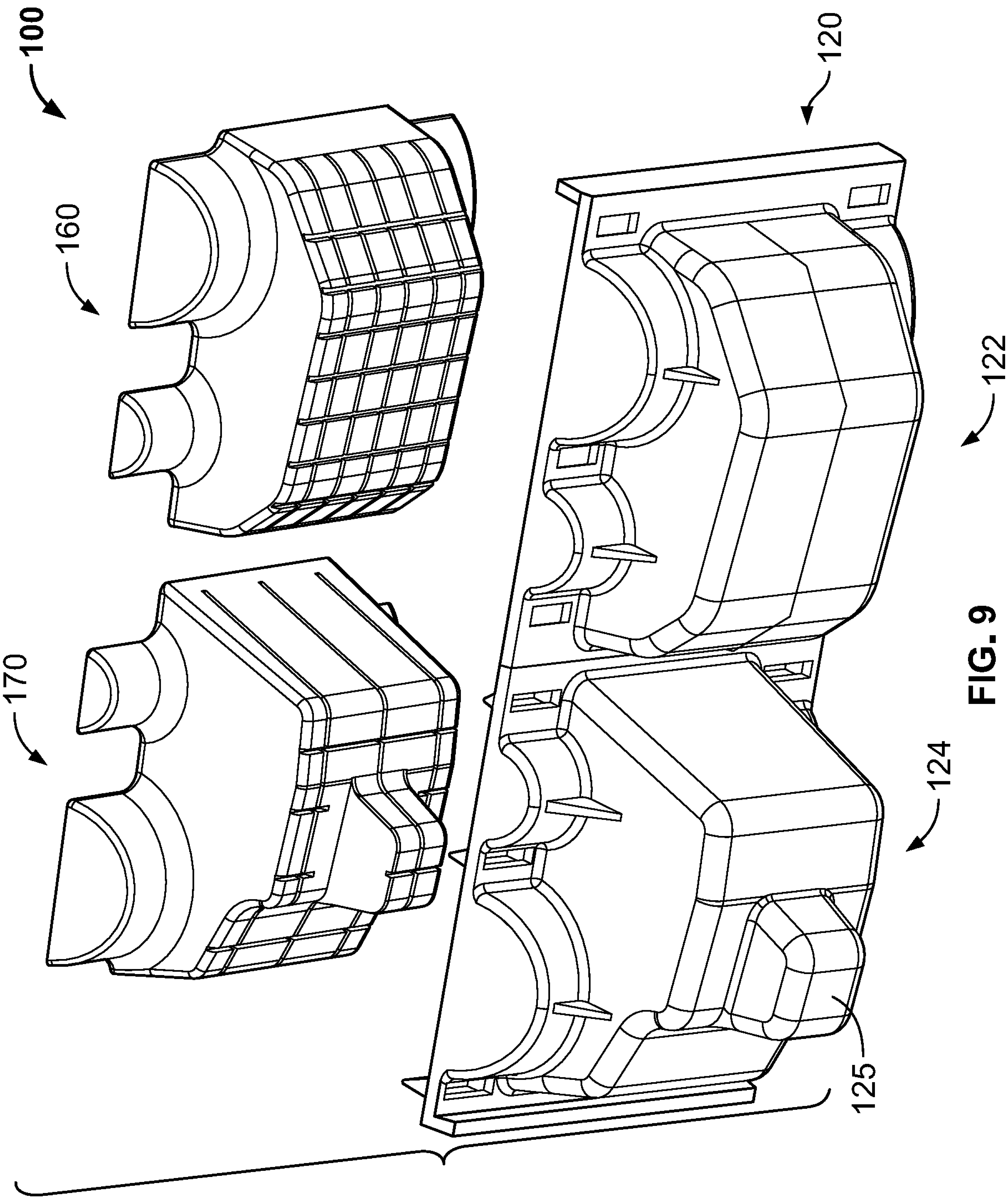
FIG. 8



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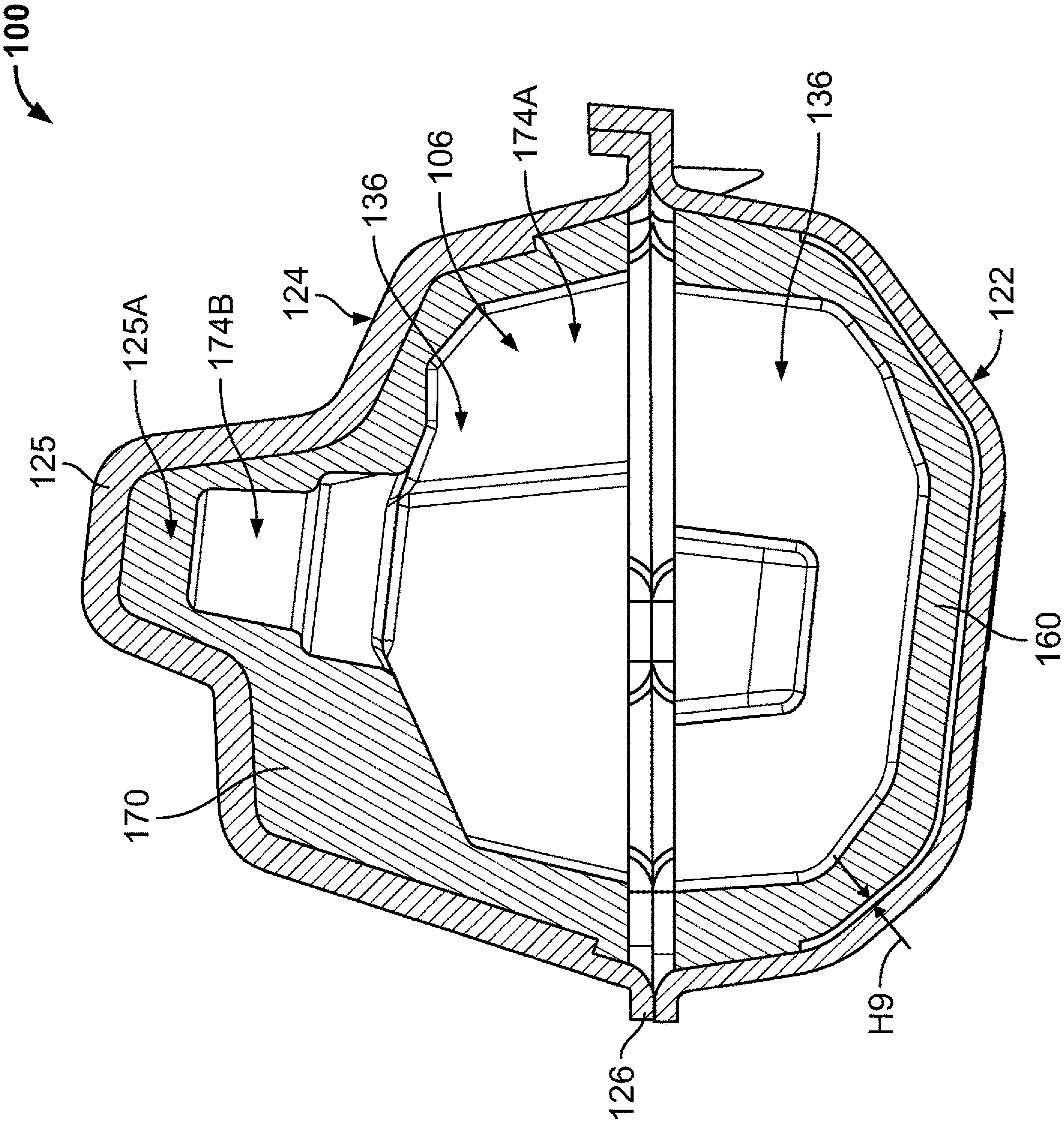

FIG. 10

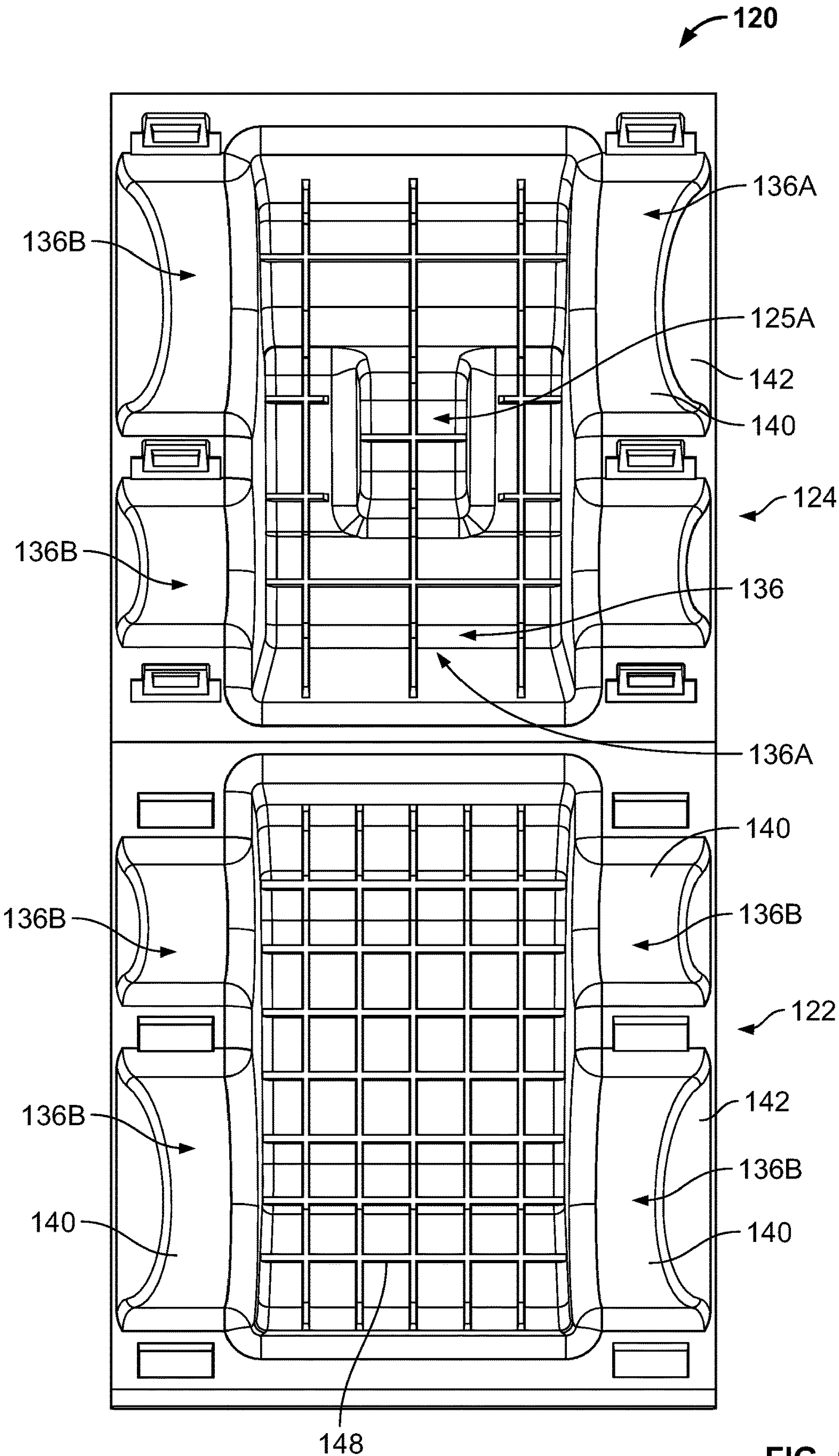
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FIG. 11

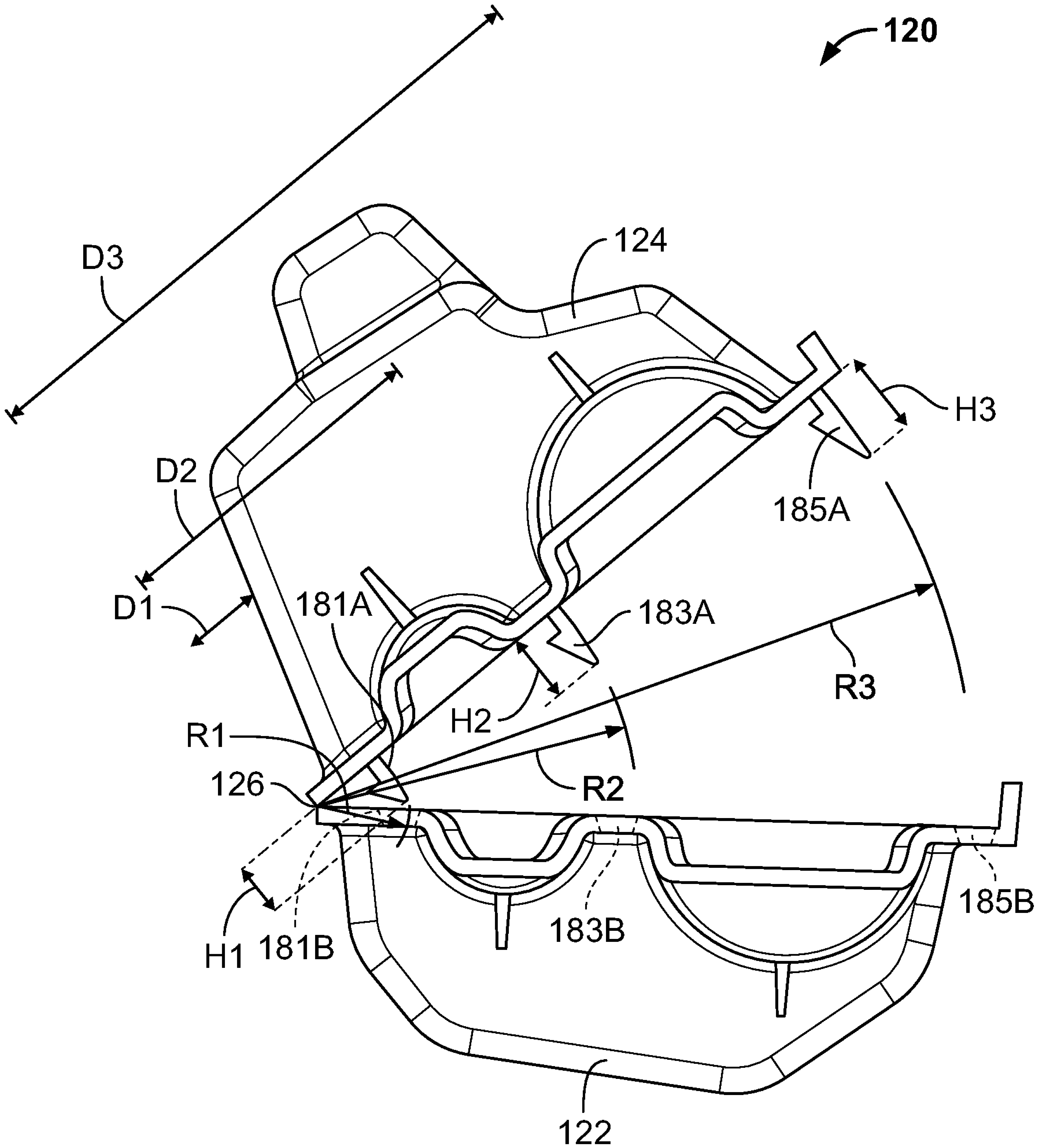
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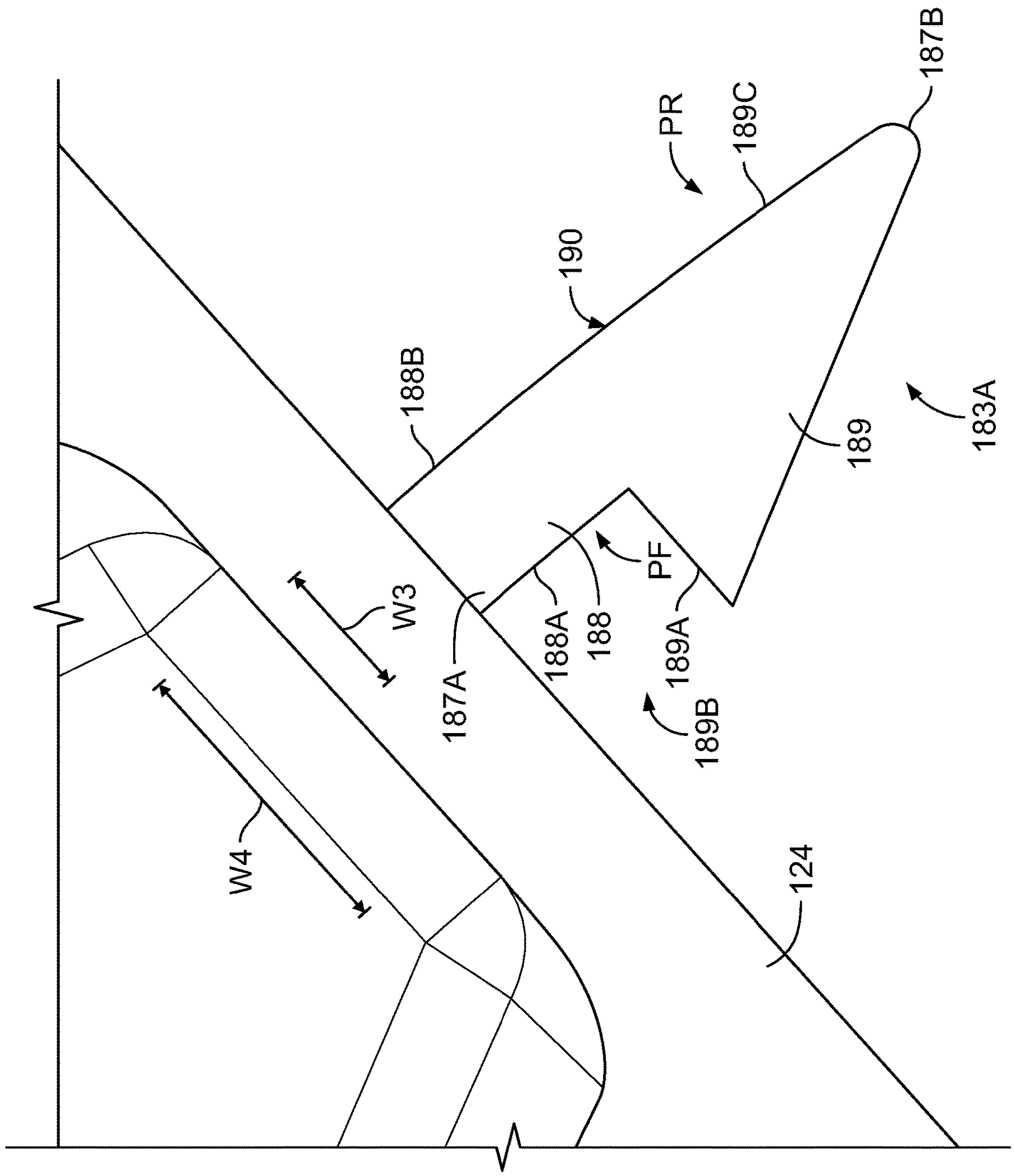
FIG. 12

FIG. 13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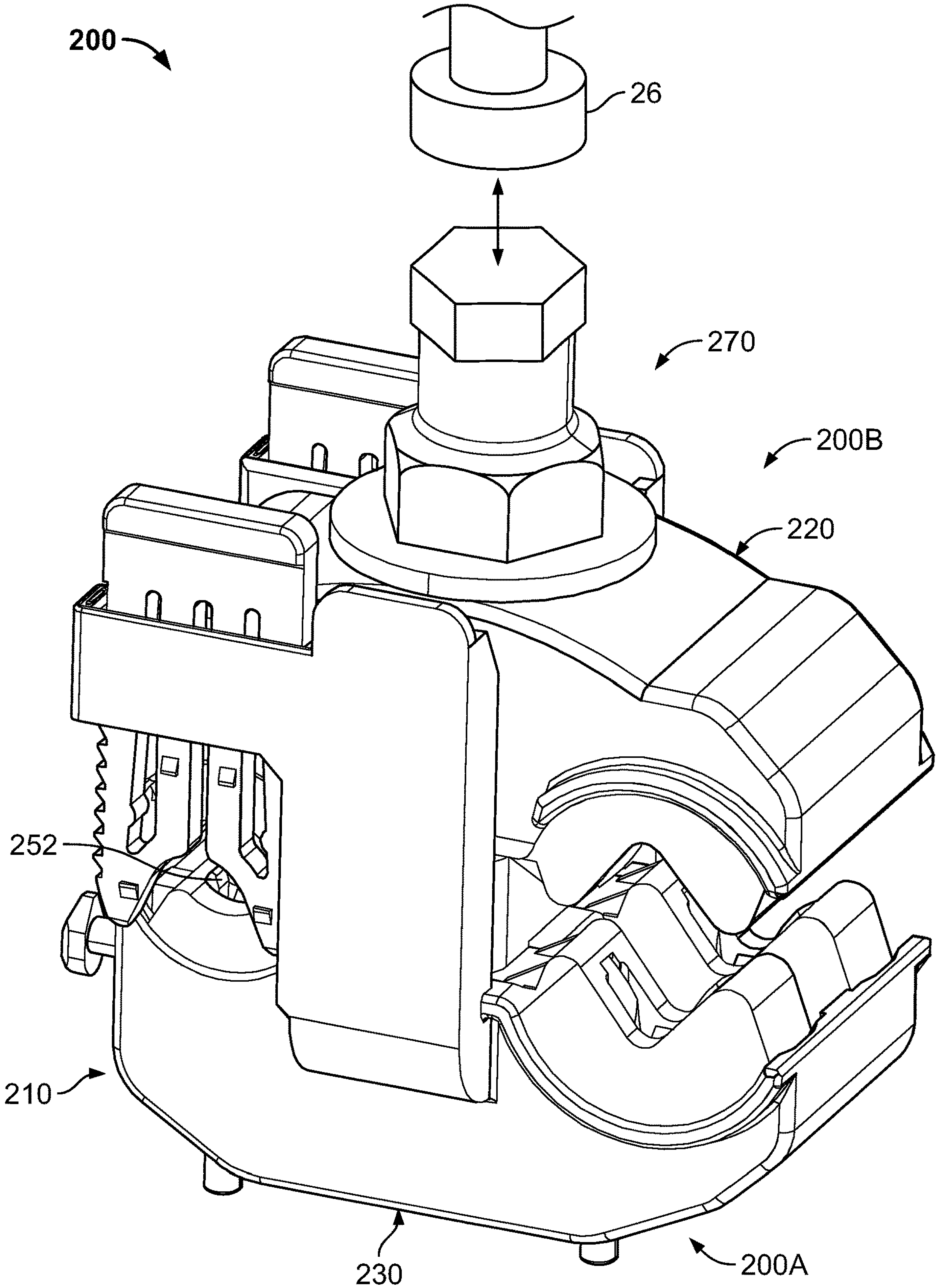

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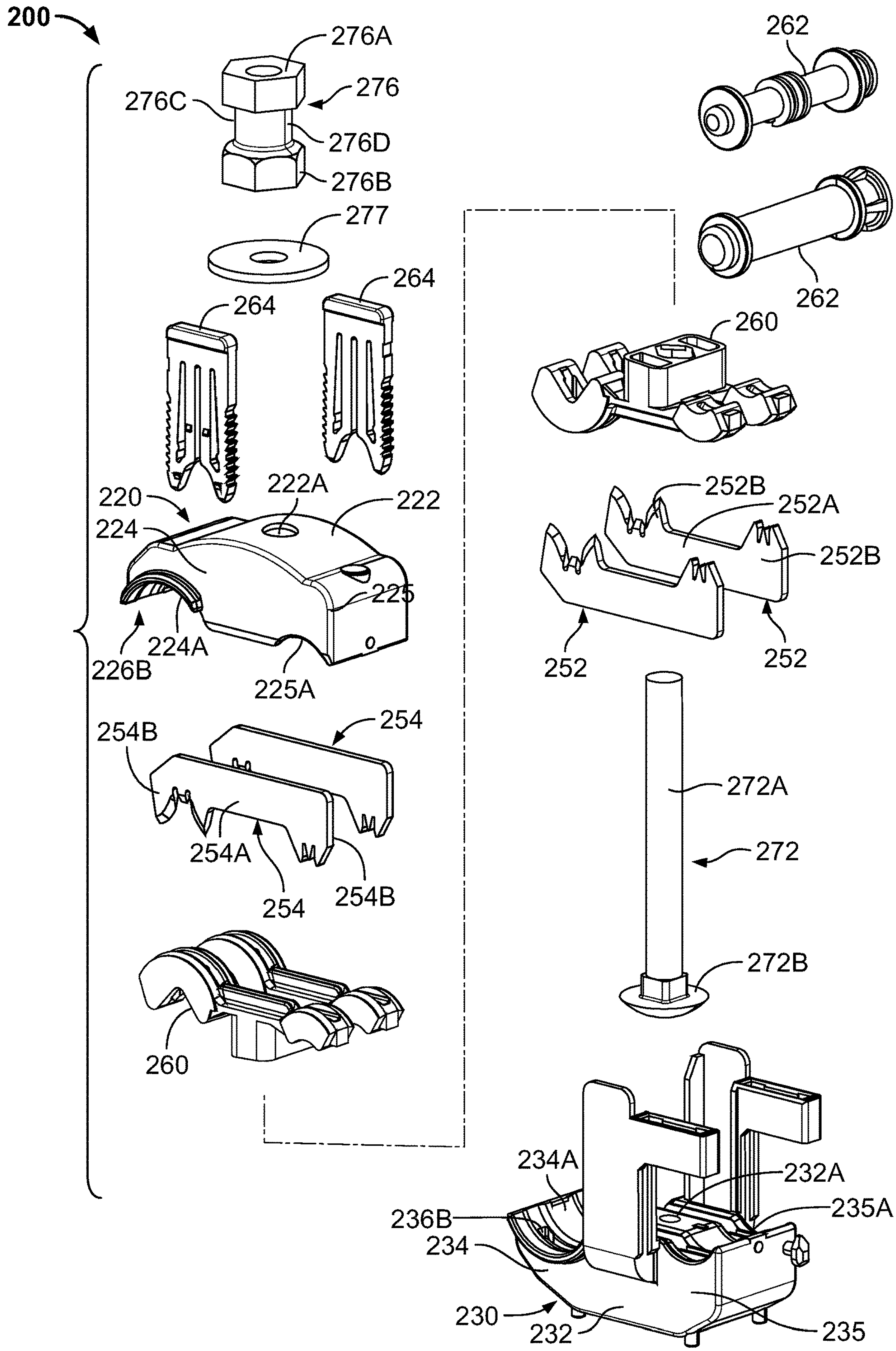

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FIG. 15

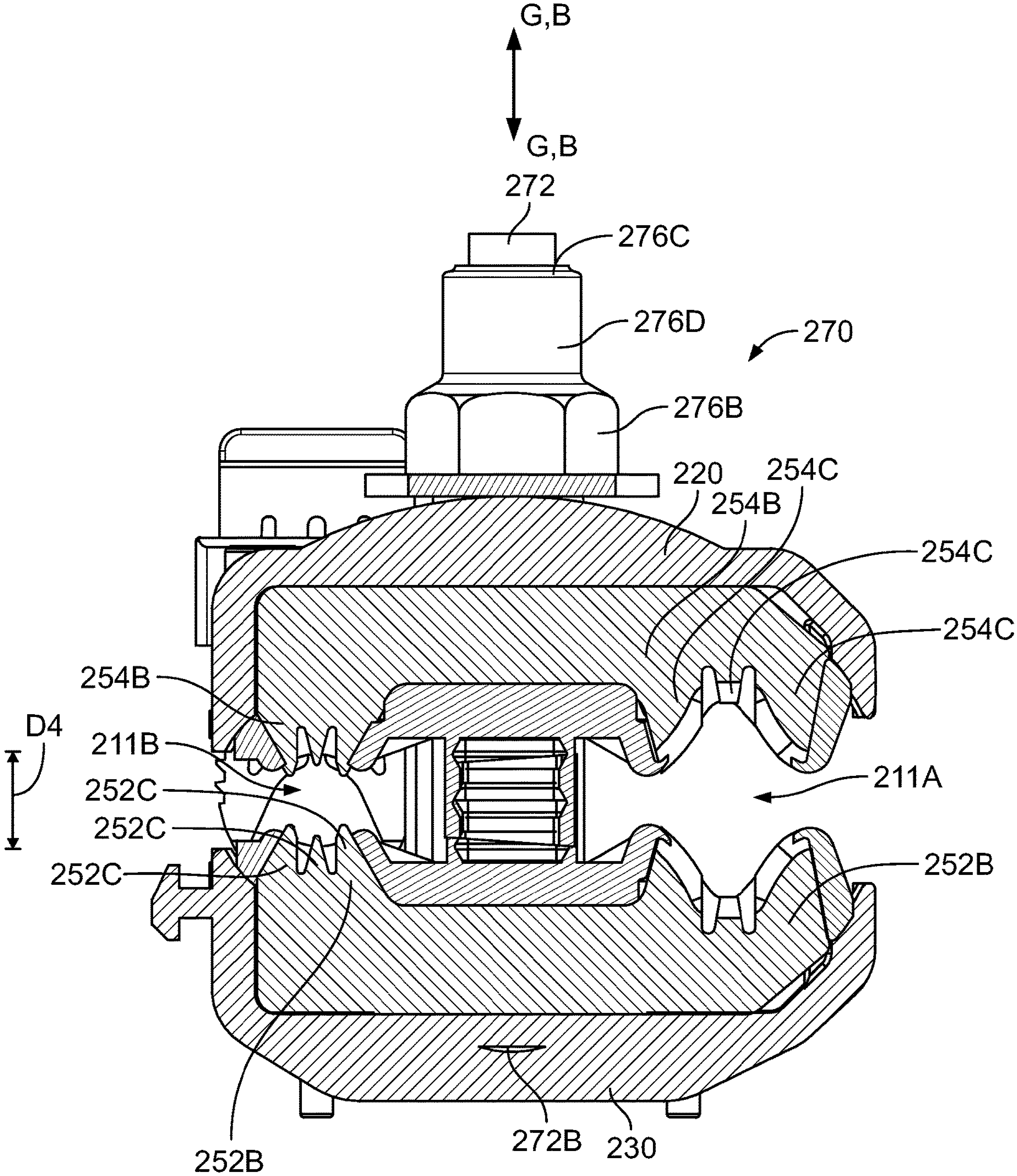
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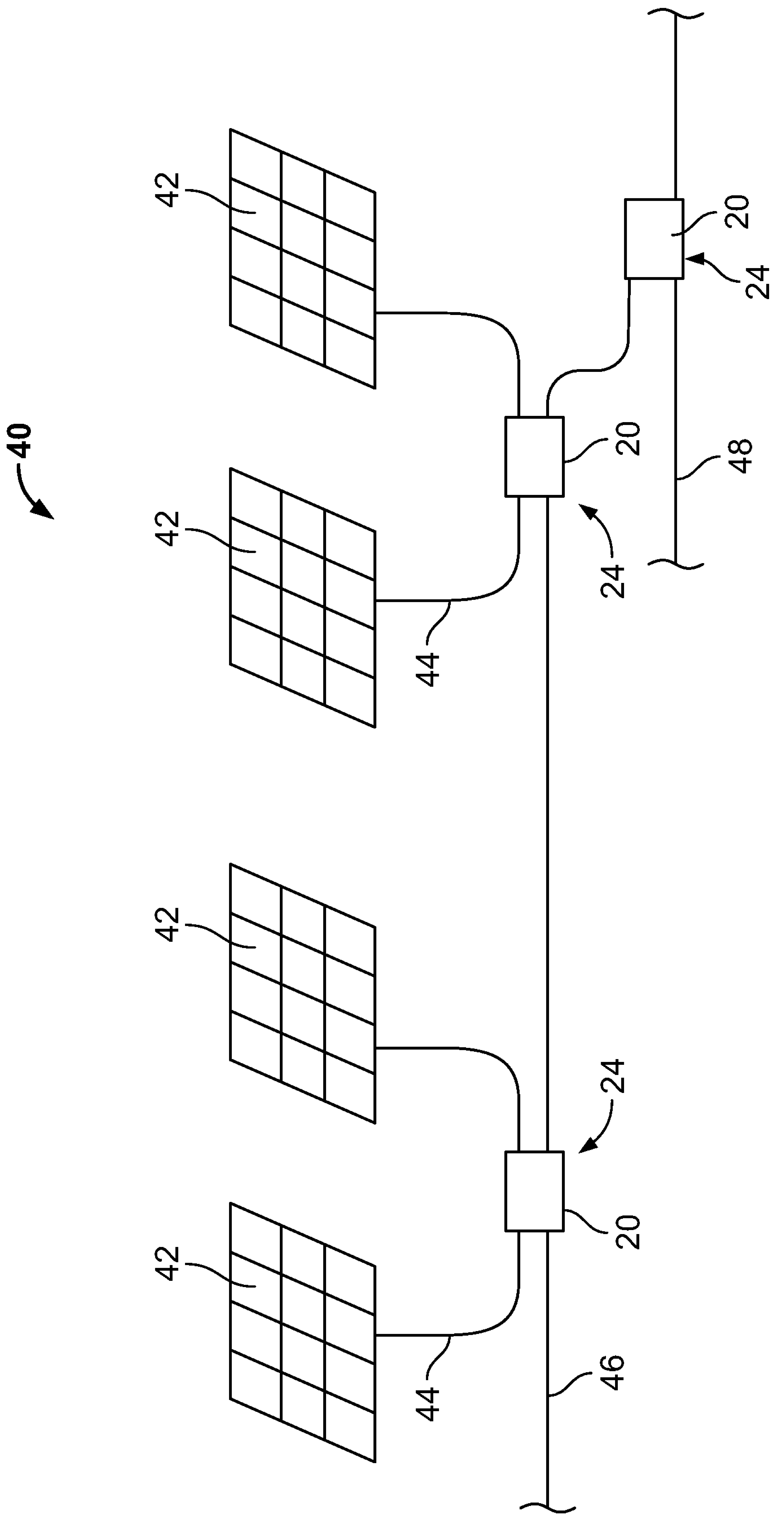
FIG. 16



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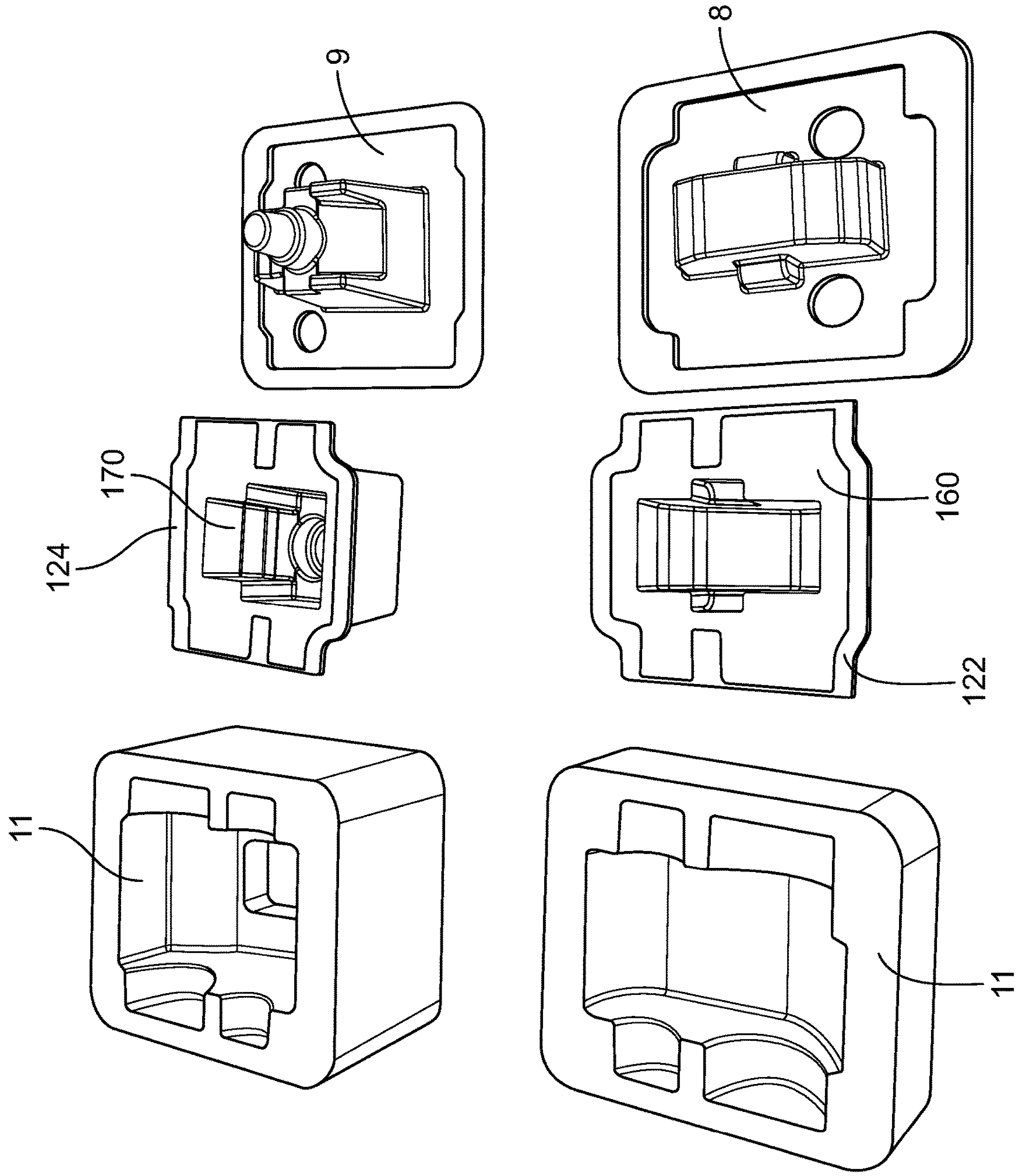

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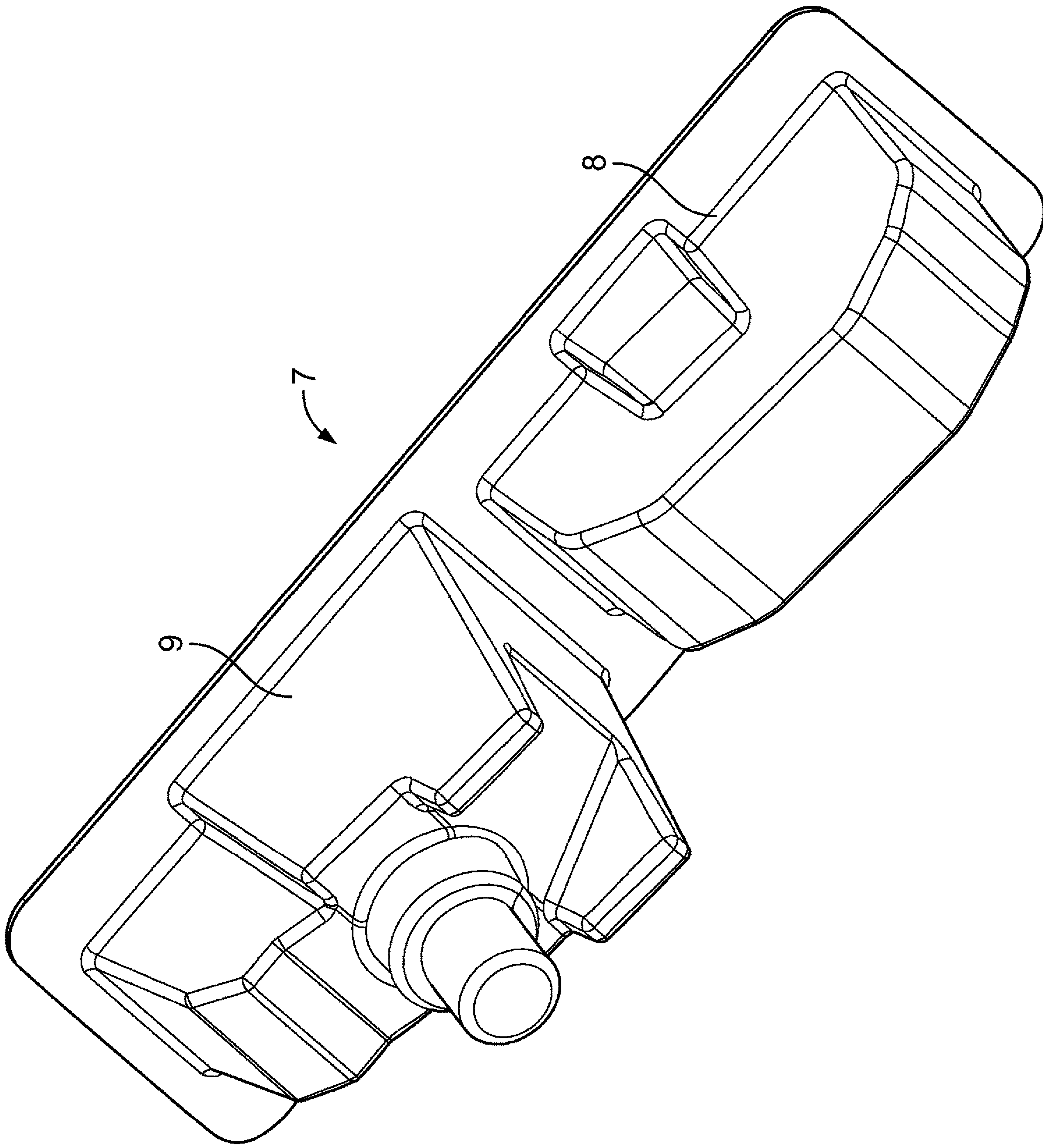

FIG. 19

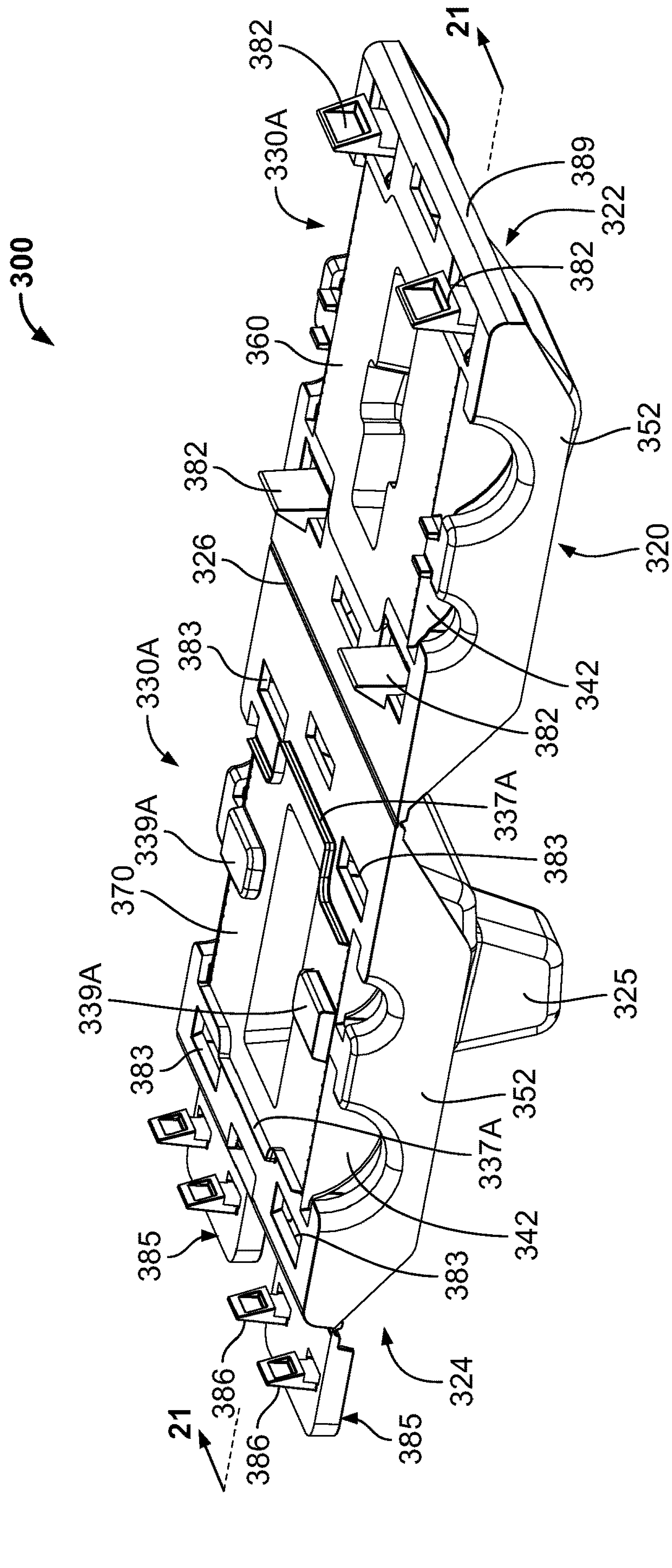
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FIG. 20

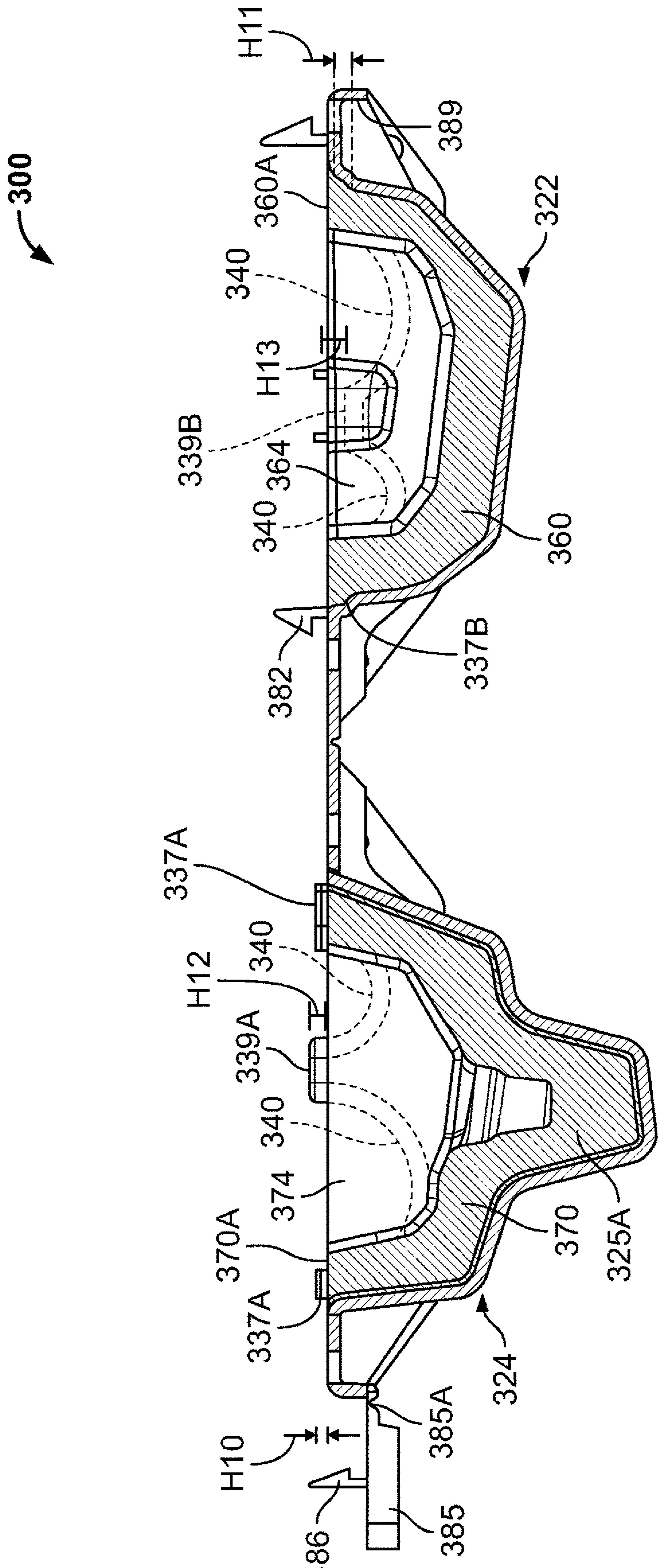
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FIG. 21

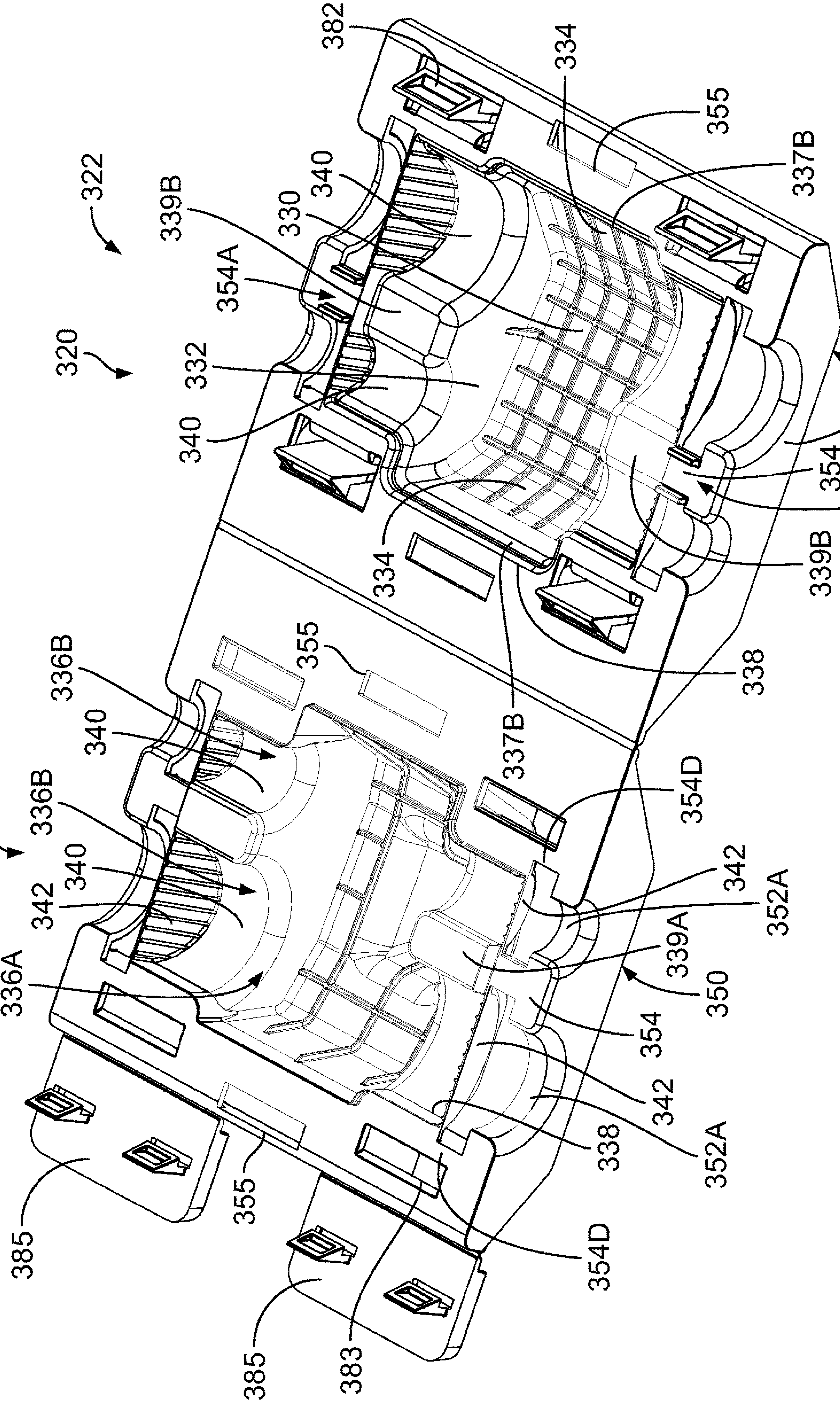
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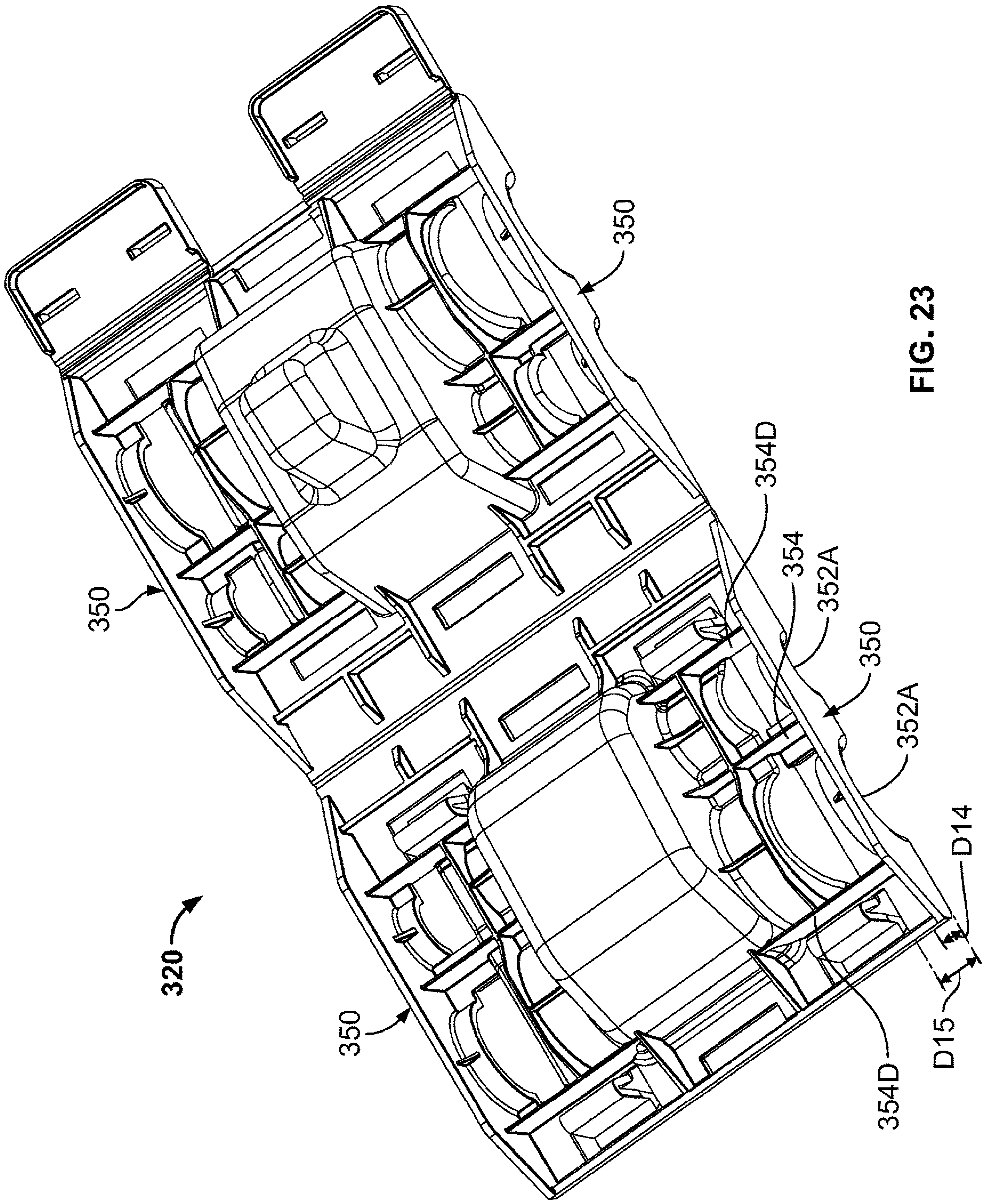
FIG. 22



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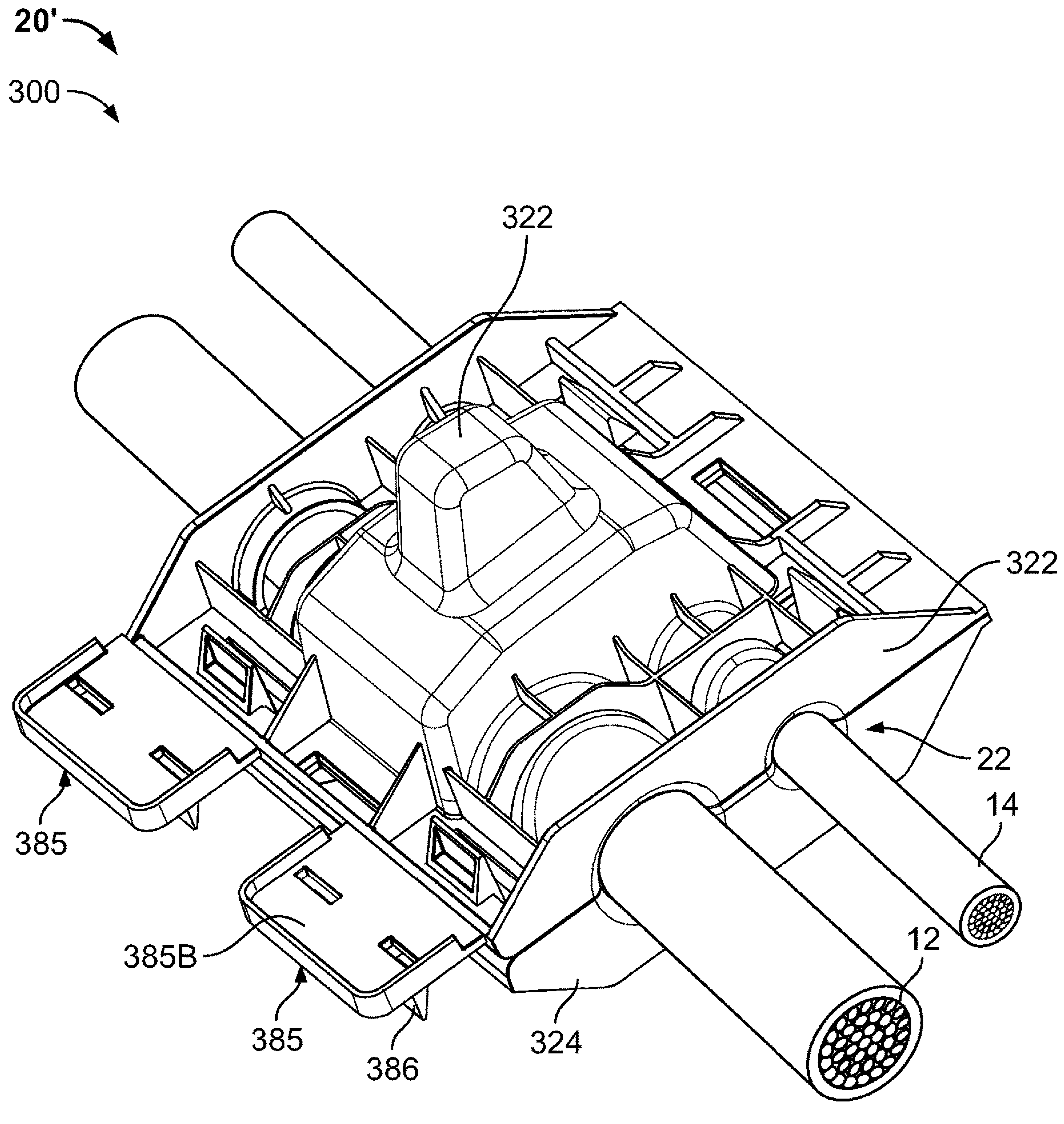

FIG. 24

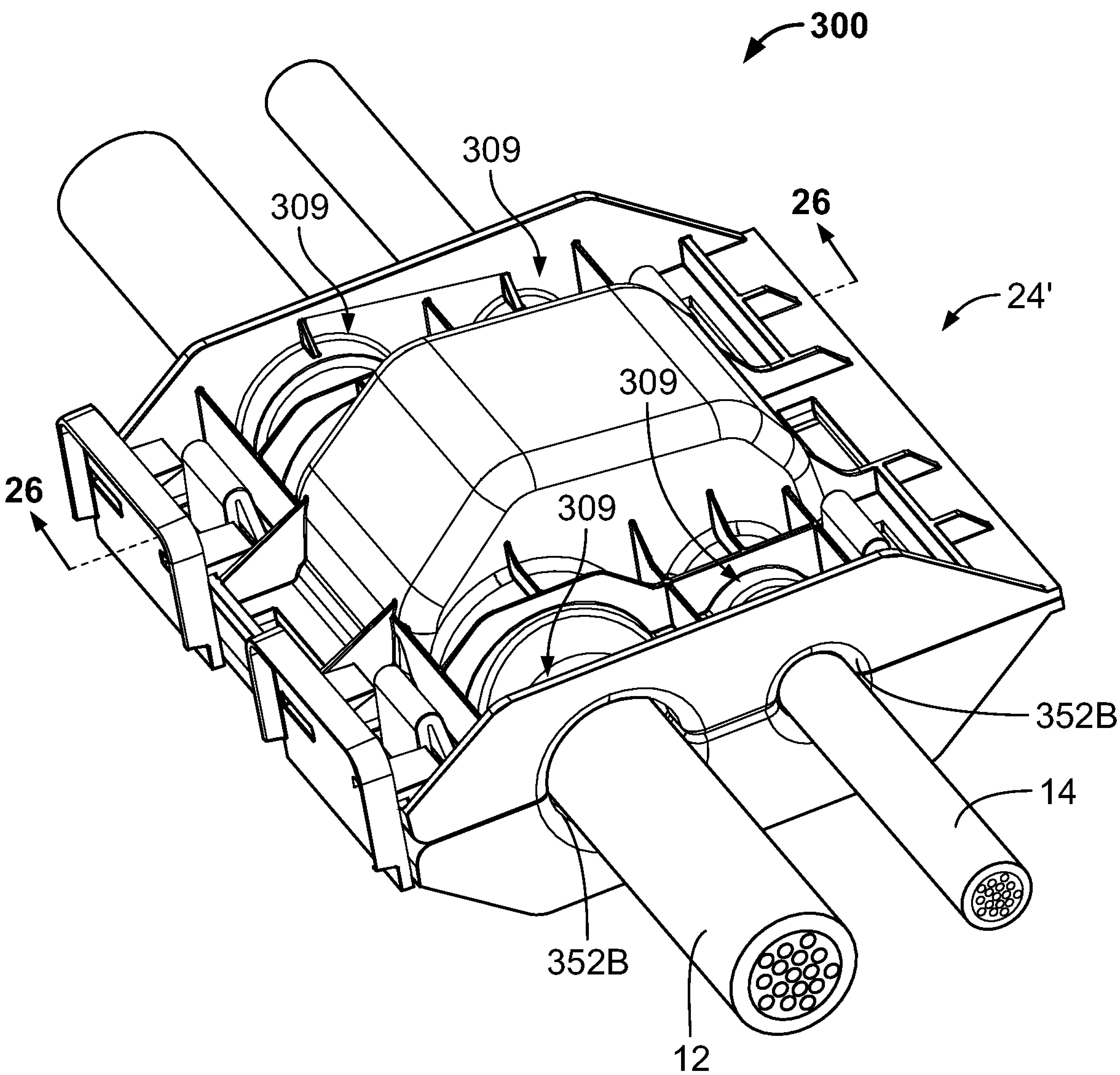

FIG. 25

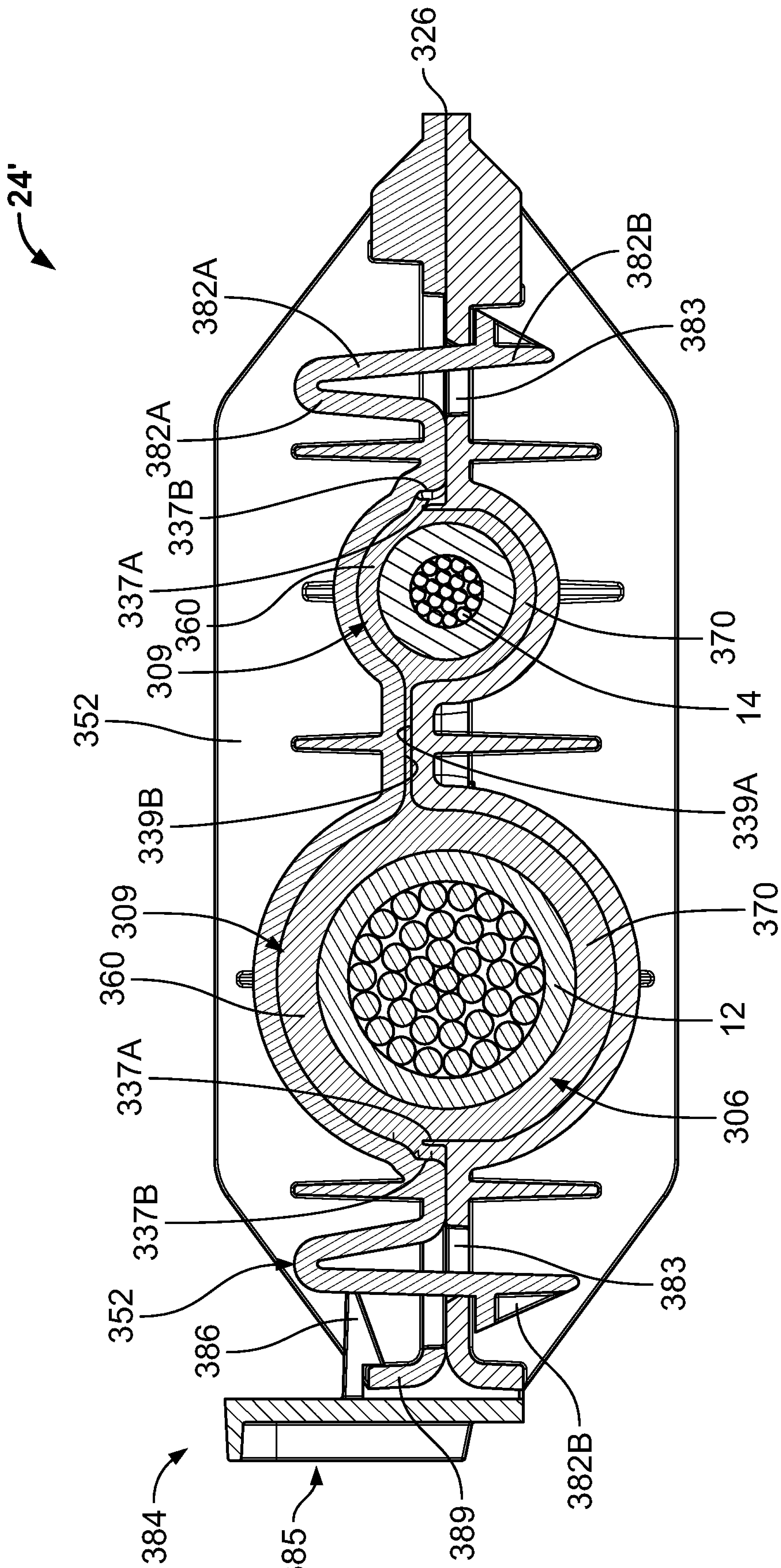
326
24'
382B
382A
383
382A
337B
337A
360
370
309
14
352
339A
339B
309
370
360
12
337A
306
337B
383
352
386
382B
384
389
385

FIG. 26

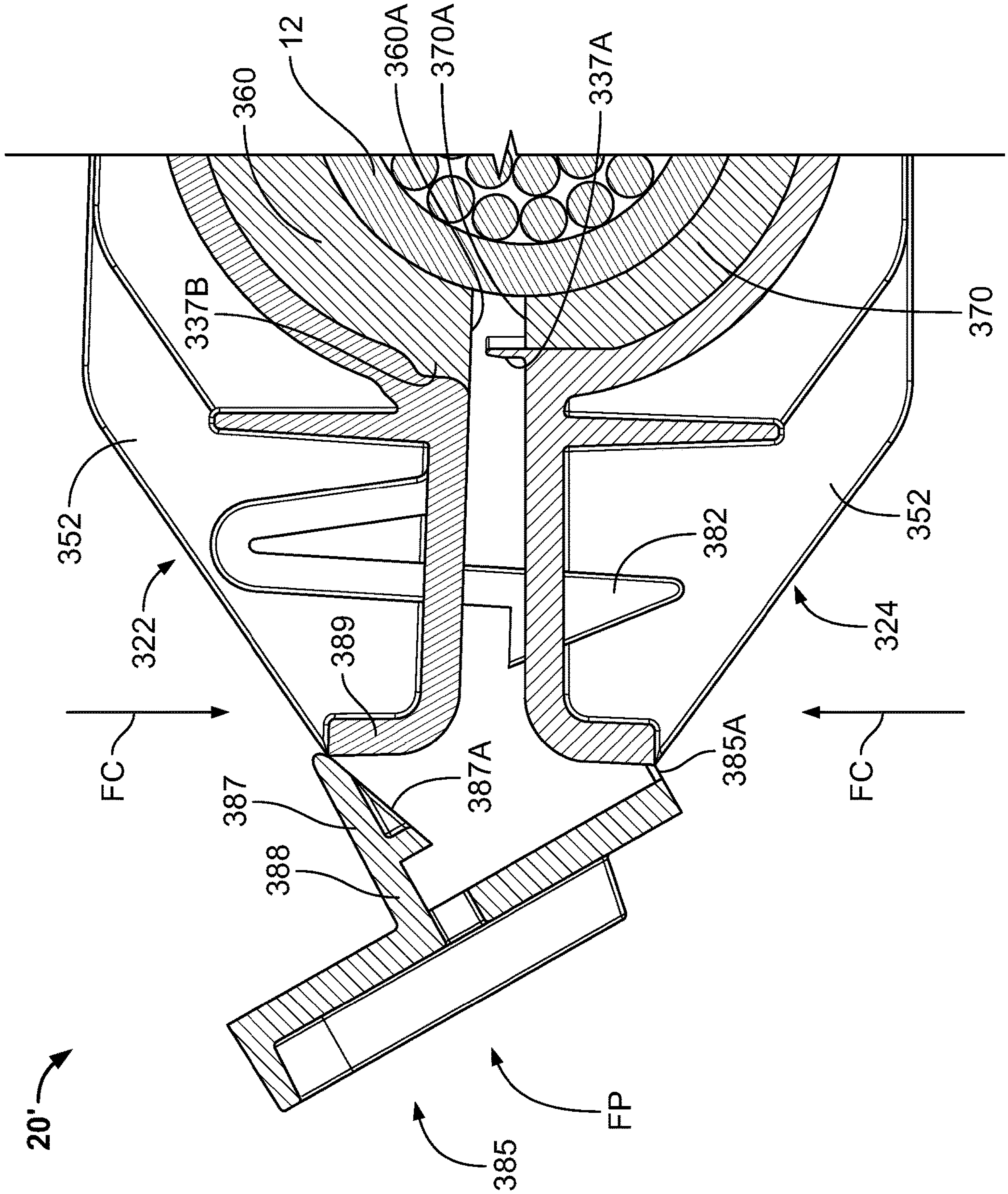
12
360
360A
370A
337A
337B
370
352
352
382
322
324
389
FC
FC
387A
385A
387
388
20'
FP
385

FIG. 27

CONNECTION ENCLOSURE ASSEMBLIES, CONNECTOR SYSTEMS AND METHODS FOR FORMING AN ENCLOSED CONNECTION BETWEEN CONDUCTORS

RELATED APPLICATION(S)

The present application claims the benefit of and priority from U.S. Provisional Patent Application No. 62/691,419, filed Jun. 28, 2018, the disclosure of which is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

The present invention relates to connectors and methods for forming connections and, more particularly, to connection enclosures and methods for connecting elongate electrical conductors.

BACKGROUND OF THE INVENTION

Electrical conductors often must be terminated or joined in various environments, such as underground or overhead. Such conductors may be, for example, high voltage electrical distribution or transmission lines. In order to form such connections, a connector may be employed. For example, in electrical power systems, it is occasionally necessary to tap into an electrical power line. One known system for tapping into an electrical power line is to use a tap connector for electrically connecting a main line electrical cable to an end of a tap line electrical conductor.

Insulation piercing (IP) connectors are commonly used to form mechanical and electrical connections between insulated cables. Typically, an IP connector includes metal piercing blades with sets of teeth on either end thereof. The piercing blades are mounted in housing members (e.g., along with environmental sealing components). The housing members are clamped about the insulated main and tap cables so that one set of teeth of a piercing blade engages the main cable and the other set of teeth of the piercing blade engages the tap cable. The teeth penetrate the insulation layers of the cables and make contact with the underlying conductors, thereby providing electrical continuity between the conductors through the piercing blade.

SUMMARY OF THE INVENTION

According to some embodiments, an enclosed connection system for mechanically and electrically connecting first and second cables, the cables each including an elongate electrical conductor covered by an insulation layer, includes an insulation piercing connector and an enclosure. The insulation piercing connector includes at least one electrically conductive piercing member and a clamping mechanism. The clamping mechanism is configured and operable to force the at least one piercing member through the insulation layers of the first and second cables and into electrical engagement with the conductors of the first and second cables to form a connection including the insulation piercing connector and the first and second cables wherein the conductors of the first and second cables are electrically connected to one another through the at least one piercing member. The enclosure is configured to receive and cover the connection and to protect the insulation piercing connector.

According to some embodiments, an enclosure assembly for use with a insulation piercing connector and first and

second elongate electrical conductors includes at least one cover member configured or configurable to define an enclosure cavity to receive the insulation piercing connector.

According to method embodiments, a method for forming an enclosed connection assembly about first and second cables, the cables each including an elongate electrical conductor covered by an insulation layer, includes providing an insulation piercing connector including: at least one electrically conductive piercing member; and a clamping mechanism configured and operable to force the at least one piercing member through the insulation layers of the first and second cables and into electrical engagement with the conductors of the first and second cables to form a connection including the insulation piercing connector and the first and second cables wherein the conductors of the first and second cables are electrically connected to one another through the at least one piercing member. The method further includes: selectively operating the clamping mechanism of the insulation piercing connector to force the at least one piercing member through the insulation layers of the first and second cables and into electrical engagement with the conductors of the first and second cables such that the conductors of the first and second cables are electrically connected to one another through the at least one piercing member to thereby form a connection; and covering the connection and protecting the insulation piercing connector with an enclosure.

According to some embodiments, a solar electrical power generation collection system includes a plurality of distributed solar electrical generation devices, a plurality of feed cables each extending from a respective one of the solar electrical generation devices, a trunk cable, and a plurality of enclosed connection systems each mechanically and electrically connecting a respective one of the feed cables to the trunk cable. Each enclosed connection system includes an insulation piercing connector and an enclosure. The insulation piercing connector includes: at least one electrically conductive piercing member; and a clamping mechanism configured and operable to force the at least one piercing member through the insulation layers of the feed and trunk cables and into electrical engagement with the conductors of the feed and trunk cables such that the conductors of the feed and trunk cables are electrically connected to one another through the at least one piercing member. The enclosure is configured to receive and cover the connection and to protect the insulation piercing connector.

According to some embodiments, an enclosure assembly for protecting an electrical connection between a connector and first and second elongate electrical conductors includes a first cover member, a second cover member, a first flowable sealant, and a second flowable sealant. The first cover member defines a first cover member cavity and includes: a first port extension forming a part of the first cover member cavity; a first strain relief slot; and a first openable port wall located between the first port extension and the first strain relief slot. The second cover member defines a second cover member cavity and includes: a second port extension forming a part of the second cover member cavity; a second strain relief slot; and a second openable port wall located between the first port extension and the first strain relief slot. The first flowable sealant is disposed in the first cover member cavity to provide a seal about the connection. The second flowable sealant is disposed in the second cover member cavity to provide a seal about the connection. The first and second cover members are relatively movable between an open position to receive the connection and a closed position wherein the first and second cover members define an enclosure cavity to contain the connection such that the connector is encapsulated in the first and second sealants. The enclosure is configured such that the connector will displace the first and second sealants when the first and second cover members are moved from the open position to the closed position about the connector. When the first and second cover members are in the closed position: the first and second port extensions combine to form a cable port; the first and second strain relief slots combine to form a strain relief opening; the first and second port walls partition the cable port from the strain relief opening; the enclosure is configured to receive the first cable such that the first cable extends from the connection in the enclosure cavity, through the cable port, through the first and second port walls, and through the strain relief opening; the first and second port walls inhibit flow of the first and second flowable sealants from the cable port toward the strain relief opening; and the strain relief opening is configured to receive a portion of the first cable to provide strain relief for the first cable.

According to some embodiments, an enclosure for protecting an electrical connection between a connector and first and second elongate electrical conductors includes first and second cover members, a main latching mechanism, and a safety latch mechanism. The first and second cover members define first and second cover member cavities, respectively. The first and second cover members are pivotally connected by a first hinge. The first and second cover members are relatively pivotable about the first hinge between an open position to receive the connection and a closed position wherein the first and second cover members define an enclosure cavity to contain the connection such that the connector is encapsulated in the first and second cover members. The main latch mechanism includes: a first latch feature forming a part of the first cover member; and a second latch feature forming a part of the second cover member. The safety latch mechanism includes: a safety latch member pivotally connected to the first cover member by a second hinge, the safety latch member including a first safety latch feature; and a second safety latch feature on the second cover member. The first and second latch features are configured to interlock with one another when the first and second members are placed in the closed position. The safety latch member is configured to pivot about the second hinge from a ready position to a safety latching position after the first and second cover members are placed in the closed position. In the safety latching position, the first and second safety latching features are interlocked with one another.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a top perspective view of a connector system according to some embodiments in an open position.

FIG. **2** is an exploded, top perspective view of the connector system of FIG. **1**.

FIG. **3** is top perspective view of an enclosed connection assembly including the connector system of FIG. **1**.

FIG. **4** is bottom perspective view of the enclosed connection assembly of FIG. **3**.

FIG. **5** is a cross-sectional view of the enclosed connection assembly of FIG. **3** taken along the line **5-5** of FIG. **3**.

FIG. **6** is a cross-sectional view of the enclosed connection assembly of FIG. **3** taken along the line **6-6** of FIG. **5**.

FIG. **7** is a top perspective view of an enclosure assembly forming a part of the connector system of FIG. **1**.

FIG. **8** is an exploded, top perspective view of the enclosure assembly of FIG. **7**.

FIG. **9** is an exploded, bottom perspective view of the enclosure assembly of FIG. **7**.

FIG. **10** is a cross-sectional view of the enclosure assembly of FIG. **7** in a closed position.

FIG. **11** is a top view of a housing forming a part of the enclosure assembly of FIG. **7**.

FIG. **12** is a side view of the housing of FIG. **11** in a partially closed position.

FIG. **13** is an enlarged, fragmentary, side view of the housing of FIG. **11**.

FIG. **14** is a top perspective view of an insulation piercing connector forming a part of the connector system of FIG. **1**.

FIG. **15** is an exploded, top perspective view of the insulation piercing connector of FIG. **14**.

FIG. **16** is a side view of the insulation piercing connector of FIG. **14**.

FIG. **17** is a solar electrical power generation collection system including a plurality of the connector systems of FIG. **1**.

FIG. **18** is a top perspective view illustrating manufacture of the enclosure assembly of FIG. **7**.

FIG. **19** is a bottom perspective view of an alternative spacer insert for manufacture of the enclosure assembly of FIG. **7**.

FIG. **20** is a top perspective view of an enclosure assembly according to further embodiments in an open position.

FIG. **21** is a cross-sectional view of the enclosure assembly of FIG. **20** taken along the line **21-21** of FIG. **20**.

FIG. **22** is a top perspective view of a housing forming a part of the enclosure assembly of FIG. **20**.

FIG. **23** is a bottom perspective view of the housing of FIG. **22**.

FIG. **24** is a top perspective view of the enclosure assembly of FIG. **20** partially installed on a connection.

FIG. **25** is a top perspective view of an enclosed connection including the enclosure assembly of FIG. **20** in a closed position.

FIG. **26** is a cross-sectional view of the enclosure connection of FIG. **25** taken along the line **26-26** of FIG. **25**.

FIG. **27** is an enlarged, fragmentary, cross-sectional view of the enclosure connection of FIG. **25**.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which illustrative embodiments of the invention are shown. In the drawings, the relative sizes of regions or features may be exaggerated for clarity. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art.

It will be understood that when an element is referred to as being “coupled” or “connected” to another element, it can be directly coupled or connected to the other element or intervening elements may also be present. In contrast, when an element is referred to as being “directly coupled” or “directly connected” to another element, there are no intervening elements present. Like numbers refer to like elements throughout.

In addition, spatially relative terms, such as “under”, “below”, “lower”, “over”, “upper” and the like, may be used herein for ease of description to describe one element or feature’s relationship to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as "under" or "beneath" other elements or features would then be oriented "over" the other elements or features. Thus, the exemplary term "under" can encompass both an orientation of over and under. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. As used herein the expression "and/or" includes any and all combinations of one or more of the associated listed items.

Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of this disclosure and the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

As used herein, "monolithic" means an object that is a single, unitary piece formed or composed of a material without joints or seams.

With reference to FIGS. **1**-**16**, a connector system **20** according to embodiments of the present invention may be used to form an enclosed and protected connection assembly **24**. The connector system **20** includes an insulation piercing connector **200** (which may be referred to herein as an IPC, IP connector, or IPC connector) and an enclosure assembly **100**. The connector **200** can be used to form an IPC connection **22** (FIG. **1**) including a pair of elongate conductor cables **12**, **14** (e.g., electrical power lines) mechanically and electrically coupled by the connector **200**. Generally, and as described in more detail below, a driver **26** (FIG. **14**) may be used to secure the connector **200** on the cables **12**, **14**. The enclosure assembly **100** according to embodiments of the present invention may be installed on and surround the connection **22** to form the enclosed connection assembly **24**.

The connector **200** is a multi-cable insulation piercing connector. The connector **100** may be adapted for use as a splice or tap connector for connecting an elongate electrical tap or feed cable **14** to an elongate main cable **12** of a utility power distribution system, for example. The connected cables **12**, **14** may be other combinations of cables such as spliced cables.

The second cable **14** may be a known electrically conductive metal high, medium or low voltage cable or line having a generally cylindrical form in an exemplary embodiment. The first cable **12** may also be a generally cylindrical high, medium or low voltage cable line. The cable **14** includes a metal electrical conductor **14**A surrounded by an insulation layer **14**B. The cable **12** includes a metal electrical conductor **12**A surrounded by an insulation layer **12**B. One or more of the conductors **12**A, **14**A may be formed of multiple strands (e.g., parallel or twisted strands) as illustrated in the figures, or may be solid cylindrical conductors (solid wire). Multi-strand conductors may be easier to handle with better bending characteristics. Suitable materials for the conductors **12**A, **14**A may include aluminum or copper. The insulation layers **12**B, **14**B may be formed of a polymeric material such as PVC, polypropylene, polyethylene, or cross-linked polyethylene. The conductor **14**A and the conductor **12**A may be of the same wire gauge or different wire gauge in different applications and the connector **100** is adapted to accommodate a range of wire gauges for the conductor **14**A and the conductor **12**A. In some embodiments, the conductor **12**A has a larger cross-sectional diameter than the conductor **14**A. The cable **12** has a lengthwise axis E-E and the cable **14** has a lengthwise axis F-F.

When installed on the first cable **12** and the second cable **14**, the connector **200** provides electrical connectivity between the conductor **12**A and the conductor **14**A. This connection may be used to feed electrical power from the main conductor **12**A to the tap conductor **14**A in, for example, an electrical utility power distribution system. Or, as discussed below with reference to FIG. **17**, the connection may be used to feed electrical power to the main conductor **12**A from a feed conductor **14**A in an electrical power generation system, for example. The power distribution or generation system may include a number of main cables of the same or different wire gauge, and a number of tap or feed cables of the same or different wire gauge.

With reference to FIGS. **14**-**16**, the connector **200** includes a connector body assembly **210**, a first pair of blade members **252** (hereinafter, the "lower blade members"), a second pair of blade members **254** (hereinafter, the "upper blade members"), seal members **260**, cable end caps **262**, end cap retainers **264** and a clamping or compression mechanism **270**. The connector **200** has a longitudinal axis G-G.

The connector body assembly **210** includes a first or upper body member **220**, and a second or lower body member **230**.

The upper body member **220** includes a support portion **222** and a pair of laterally opposed legs or jaw portions **224**, **225** extending laterally from the support portion **222** with respect to the connector axis G-G. The support portion **222** includes a bore **222**A. The jaw portion **224** includes a cable groove or seat **224**A. The jaw portion **225** includes a cable groove or seat **225**A. The jaw portion **224** further includes, in the cable seat **224**A, a pair of blade slots or seats **224**B. The jaw portion **225** further includes, in the cable seat **225**A, a pair of blade slots or seats **226**B.

The lower body member **230** includes a support portion **232** and a pair of laterally opposed legs or jaw portions **234**, **235** extending laterally from the support portion **232** with respect to the connector axis G-G. The support portion **232** includes a bore **232**A. The jaw portion **234** includes a cable groove or seat **234**A. The jaw portion **235** includes a cable groove or seat **235**A. The jaw portion **234** further includes, in the cable seat **234**A, a pair of blade slots or seats **234**B. The jaw portion **235** further includes, in the cable seat **235**A, a pair of blade slots or seats **236**B.

The jaw portion **224** and the jaw portion **234** define a first or main side cable receiving slot **211**A therebetween. The jaw portion **225** and the jaw portion **235** define a second or tap side cable receiving slot **211**B therebetween.

The body members **220**, **230** may be formed of any suitable material. According to some embodiments, the body members **220**, **230** are formed of a polymeric material. In some embodiments, the polymeric material is selected from the group consisting of polyamide (PA) 6.6, PA 6.6 reinforced with glass fibers or talc, polycarbonate, or polycarbonate blend. The body members **220**, **230** may be formed using any suitable technique. According to some embodiments, the body members **220**, **230** are molded. According to some embodiments, the each of the body members **220**, **230** is monolithic and unitarily formed.

The compression mechanism **270** includes a bolt **272**, and a torque control member in the form of a nut **276**. A washer **277** may be provided between the nut **276** and the upper body member **220**. However, other types of compression mechanisms may be used for the compression mechanism **270**. For example, the compression mechanism may include an inclined surface device operable to provide mechanical advantage, for example.

The bolt **272** may be a carriage bolt and includes a threaded shank **272**A, and a head **272**B.

In some embodiments and as shown, the nut **276** is a shear nut including a shear head **276**A, a base portion **276**B, a shear or breakaway section **276**C coupling the portions **276**A and **276**B, and a tubular, internally threaded connecting section **276**D extending from the base portion **276**B to the breakaway section **276**C.

The bolt **272** extends through the bores **222**A, **232**A and is axially constrained by the bolt head **272**B and the body member **230**. The nut **276** is rotatably mounted on the bolt **272** and is axially constrained by the body member **220**. The bores **222**A, **232**A may be round, or elongated, so that the upper connector body can rock as it is torqued down against two conductors with different outer diameters.

The axial spacing distance D**4** (FIG. **16**) between the cable seats **224**A, **234**A and **225**A, **235**A can be varied. The body member **220** can slide up and down the bolt **272** relative to the lower body member **230** another along a slide axis B-B. Accordingly, the heights of the slots **211**A, **211**B can be independently varied.

In use, the shear head **276**A of the nut **276** is engaged by a driver and forcibly rotated thereby. The shear head **276**A may be faceted or otherwise shaped to mate with the tool. The nut **276** is thereby rotated relative to the axially and bolt **272**, which may be rotationally constrained by a tool or an anti-rotation feature or mechanism of the connector **200**. This causes the bolt **272** to translate up through the nut **276**, which slides or translates the body portions **220** and **230** together (in respective converging directions) along the slide axis B-B. The shear head **276**A will shear off of the base portion **276**B at the breakaway section **276**C when subjected to a prescribed torque. The base portion **276**B may be faceted or otherwise configured to mate with a tool to enable loosening of the nut **276** to permit removal of the connector **200** from the cables.

According to some embodiments, the bolt **272** and the nut **276** may be formed of any suitable materials, such as steel (e.g., galvanized steel or stainless steel), aluminum alloy, plastic or zinc alloy.

Each lower blade member **252** is mounted in one of the blade slots **236**B for movement with the upper body member **230**. Each lower blade member **252** includes a body or base **252**A having laterally opposed ends. Each end is provided with an integral cable engagement or insulation piercing feature **252**B. Each insulation piercing feature **252**B includes a plurality of serrations or teeth **252**C separated by slots and having terminal points. The points of the teeth **252**C may collectively lie on an arc generally corresponding to the profile of the arcuate outer surface of the corresponding cable conductor **12**A, **14**A.

Each upper blade member **254** is mounted in one of the blade slots **226**B for movement with the upper body member **220**. Each main blade member **254** includes a body or base **254**A having axially opposed ends. Each end is provided with an integral cable engagement or insulation piercing feature **254**B. Each insulation piercing feature **254**B includes a plurality of serrations or teeth **254**C separated by slots and having terminal points. The points of the teeth **254**C may collectively lie on an arc generally corresponding to the profile of the arcuate outer surface of the corresponding cable conductor **12**A, **14**A.

The blade members **252**, **254** are affixed in their respective blade seats such that the teeth **254**C of the blade members **254** face the teeth **252**C of the blade members **252**.

According to some embodiments, the width of each blade member **252**, **254** is at least ten times its thickness. According to some embodiments, the thickness of each the blade member **252**, **254** is in the range of from about 0.05 and 0.125 inch.

The blade members **252**, **254** may be formed of any suitable electrically conductive material. According to some embodiments, the blade members **252**, **254** are formed of metal. According to some embodiments, the blade members **252**, **254** are formed of aluminum, aluminum alloy, or copper and may be galvanized. The blade members **252**, **254** may be formed using any suitable technique. According to some embodiments, each blade members **252**, **254** is monolithic and unitarily formed. According to some embodiments, each blade member **252**, **254** is extruded and cut, stamped (e.g., die-cut), cast and/or machined.

The sealant-filled enclosure **100** includes a housing **120** and masses of sealant **160**, **170** disposed therein. According to some embodiments, and as discussed in more detail below, the sealant **160**, **170** may be a gel. The housing **120** includes a first shell or cover member **122** and a second shell or cover member **124** joined to one another by a hinge **126** and adapted to move between an open position as shown in FIG. **1** and a closed position as shown in FIG. **3**. In other embodiments, the cover members **122**, **124** are not hinged. In the open position, the enclosure assembly **100** can receive the connection **22** and adjacent portions of the cables **12**, **14**. In the closed position, the enclosure assembly **100**, including the masses of sealant **160**, **170**, may operate to seal about and protect the connection **22**. In the closed position, the enclosure assembly **100** defines an enclosure cavity **106** (FIG. **10**) and opposed pairs of ports **109** (FIG. **6**) communicating with the enclosure cavity **106**. The shape or geometry of the enclosure cavity **106** resembles or substantially conforms that of the connector **200**.

Turning to the housing **120** in more detail, the cover members **122**, **124** are constructed in generally the same manner, except for the shapes of their cavities, the shapes of their outer profiles, and the configurations of their latch structures.

Each cover member **122**, **124** includes a bottom wall **130**. Opposed side walls **132** and opposed end walls **134** extend upwardly from the bottom wall **130**. Opposed pairs of port extensions **140** extend longitudinally from either end of each cover member **122**, **124**. Each port extension **140** is terminated by a port wall **142**. Each part wall **142** is configured and constructed to be opened or displaced to receive a cable in the port extension **140**. In some embodiments, the port wall **142** is a breakaway wall. In some embodiments, the port walls **142** are frangible (i.e., the port wall **142** is constructed to be broken open and away by breaking (e.g., tearing) the port wall **142**). For example, the port walls **142** may include corrugations comprising a series of fingers joined by relatively thin membranes as shown, and the port wall **142** may be opened by tearing two or more of the fingers apart at one or more of the membranes.

The upper edges of the walls **132**, **134** form a perimeter edge **138** defining an opening. The walls **130**, **132**, **134** and the port extensions **140** of each cover member **122**, **124** define an overall cover member chamber or cavity **136** and a front opening **130**A communicating with cavity **136**. The cavity **136** includes a main cavity portion **136**A and conductor port subchannels **136**B defined within each port extension **140**.

The cover member **124** further includes a dome **125** defined in its bottom wall **130**. The dome **125** defines an extension cavity **125**A. The extension cavity **125**A is contiguous with and communicates with the main cavity **136** of the cover member **124**.

The cover members **122**, **124** are pivotably joined by the hinge **126**. According to some embodiments, the hinge **126** is a flexible, living hinge. A living hinge may allow for unitary formation of the housing **120**, as well as possible cost savings in materials and assembly. Alternatively, other hinge configurations may be employed. For example, the hinge **126** may be replaced by or supplemented with interlocking pivotally coupled hinge structures and/or a pivot pin. Alternatively, the cover members **122**, **124** may be non-hinged.

The housing **120** includes a latch system including six integral latch mechanisms **181**-**186**. The latch mechanisms **181**-**186** include latch fingers **181**A-**186**A, respectively, on and projecting inwardly from the cover member **124**. The latch mechanisms **181**-**186** further include latch slots or openings **181**B-**186**B, respectively, in the cover member **122**. The latch fingers **181**A-**186**A may be integrally formed with the cover member **124**. The latch fingers **181**A-**186**A and openings **181**B-**186**B can be selectively engaged, whereupon they cooperate to releasably secure the cover members **122**, **124** in a closed configuration as shown in FIG. **3**.

The latch fingers **181**A-**186**A each have generally the same configuration except in their dimensions and relative proportions. The latch finger **183**A will be described in more detail below (FIG. **13**). However, it will be appreciated that this description likewise applies to each of the other latch fingers **181**A, **182**A, **184**A, **185**A, **186**A, except as discussed herein.

The latch finger **183**A has an inner or base end **187**A, an outer or lead end **187**B, a base section **188**, and a barb or interlock section **189**. The base section **188** extends from the base end **187**A at the perimeter **138** of the cover member **124** to the interlock section **189**. The interlock section **189** extends from the base section **188** to the lead end **187**B.

The base section **188** has a reduced width W**3** defined between a front edge **188**A and a rear edge **188**B.

The interlock section **189** has an extended ledge surface **189**A that projects widthwise beyond the inner edge **188**A to define a socket, recess, or slot **189**B between the ledge **189**A and the perimeter **138**. The interlock section **189** has a width W**4** at the extended ledge surface **189**A that is greater than the width W**3** of the base section **188**. The interlock section **189** is tapered from the lead end **187**B to the ledge **189**A.

The interlock section **189** also has a rear edge **189**C. The rear edges **188**B and **189**C collectively form a finger rear edge **190**.

The finger rear edge **190** has a convexly curved, arcuate or rounded profile PR (with respect to the edge of the cover member **124** distal from the hinge **126**). According to some embodiments, the radius of curvature of the profile PR is centered at or substantially at the hinge axis H-H of the hinge **126**, as illustrated in FIG. **12**.

The front edge **188**A of the base section **188** may also have a convexly curved or rounded profile PF (with respect to the edge of the cover member **124** distal from the hinge **126**, or concavely curved when viewed from the hinge side). According to some embodiments, the radius of curvature of the profile PF is also centered at or substantially at the hinge axis H-H.

In some embodiments, the finger rear edge **190** of each of latch finger **181**A-**186**A has a convexly curved profile as described. In some embodiments, each of these finger rear edge profiles PR has a respective radius of curvature R**1**, R**2**, or R**3** (FIG. **12**) that is centered at or substantially at the hinge axis H-H. The radius of curvature R**1**, R**2**, R**3** of each latch finger **181**A-**186**A will depend on the distance of the respective latch finger **181**A-**186**A from the hinge axis H-H. However, the radii of curvature R**1**, R**2**, R**3** are concentric with the hinge axis H-H.

In other embodiments, some of the latch fingers **181**A-**181**B may be formed with rear edges that are not curved as described above.

Similarly, the front edges **188**A of each of the base sections **188** of the latch fingers **181**A-**186**A may also have a convexly curved profile PF. In some embodiments, each of these front edge profiles PF has a respective radius of curvature that is centered at or substantially at the hinge axis **126**. Again, the front edge radius of curvature of each latch finger **181**A-**186**A will depend on the distance of the respective latch finger **181**A-**186**A from the hinge axis H-H. However, the radii of curvature are concentric with the hinge axis.

Each pair of latch fingers **181**A-**186**A are located a different prescribed transverse distance from the hinge axis H-H. More particularly, the latch fingers **181**A and **182**A are located a distance D**1** (FIG. **12**) from the hinge axis H-H, the latch fingers **183**A and **184**A are located a distance D**2** from the hinge axis H-H, and the latch fingers **185**A and **186**A are located a distance D**3** from the hinge axis H-H. The distance D**3** is greater than the distance D**2**, and the distance D**2** is greater than the distance D**1**.

Furthermore, in some embodiments, at least one pair of the latch fingers **181**A-**186**A has a different height than that of the other pairs of the latch fingers **181**A-**186**A. In some embodiments and as shown, each pair of latch fingers **181**A-**186**A has a different height selected such that the lead ends **187**B of all of the latch fingers **181**A-**186**A begin entering their respective latch openings **181**B-**186**B at substantially the same time as the cover members **122**, **124** are closed. More particularly, the latch fingers **181**A and **182**A have a height H**1**, the latch fingers **183**A and **184**A have a height H**2**, and the latch fingers **185**A and **186**A have a height H**3**. The height H**3** is greater than the height H**2**, and the height H**2** is greater than the height H**1**. In some embodiments, the heights of the base sections **188** of each latch finger **181**A-**186**A are the same, and the different heights H**1**, H**2**, H**3** are attributable to different height (lengths) of the interlock sections **189**.

As a result of the differing latch finger heights discussed above, the latch fingers **181**A-**186**A will begin entering their respective latch openings **181**B-**186**B at substantially the same time as the cover members **122**, **124** are closed. In some embodiments, the latch fingers **181**A-**186**A will begin engage and interlock with their respective latch openings **181**B-**186**B at substantially the same time as the cover members **122**, **124** are closed.

A pattern of integral ribs **148** is provided on and project inwardly from the interior surface of each bottom wall **130**. In some embodiments, each rib **148** has a height H**9** (FIG. **10**) in the range of from about 0.025 to 0.125 inch. In some embodiments, a plurality of the ribs **148** extend transversely to others of the ribs **148** to form a matrix pattern as shown, for example.

The housing **120** may be formed of any suitable material. According to some embodiments, the housing **120** is formed of an electrically insulative material. In some embodiments, the housing **120** is formed of a vacuum formed or molded polymeric material. The housing **120** may be formed of polypropylene, nylon, polyethylene, ABS and/or PMMA. The housing **120** may be formed of a flame retardant material. The housing material may be any color or transparent.

Prior to use, the sealant **160** may be contained in the cavity **136** of the cover member **122** such that a main sealant portion **162** (FIG. **8**) of the sealant is disposed in the main cavity **136** and port sealant portions **166** are disposed in the port subchannels **136**B.

According to some embodiments, a void **164** (FIG. **8**) is pre-formed or defined in the sealant **160**. According to some embodiments, the void **164** is open to the opening **130**A. According to some embodiments, the sealant **160** fully surrounds the remainder of the void **164** so that the void **164** is spaced apart from cover member **122** (by the sealant **160**) on all sides except the top side. According to some embodiments, the sealant **160** fills the cover member cavity **136** (not including the volume of the void **164**) to a level near but not fully to the perimeter edge **138**. In other embodiments, the sealant **160** fills the cover member cavity **136** of the cover member **122** substantially fully up to the perimeter edge **138** or to any other desired level. According to some embodiments, the void **164** has sloped side walls that taper outwardly in a direction from the bottom wall **130** to the opening **130**A.

According to some embodiments, the void **164** is shaped to conform to the lower half of the connector **200**. However, the void **164** may be of any other suitable shape.

Prior to use, the sealant **170** may be contained in the cavity **136** of the cover member **124** such that a main sealant portion **172** (FIG. **8**) of the sealant is disposed in the main cavity **136** and port sealant portions **176** (FIG. **8**) are disposed in the port subchannels **136**B.

According to some embodiments, a void **174** is pre-formed or defined in the sealant **170**. According to some embodiments, the void **174** is open to the opening **130**A. According to some embodiments, the sealant **170** fully surrounds the remainder of the void **174** so that the void **174** is spaced apart from cover member **124** on all sides except the top side. According to some embodiments, the sealant **170** fills the cavity **136** of the cover member **124** to a level near but not fully to the perimeter edge **138**. In other embodiments, the sealant **170** fills the cover member cavity **136** (not including the volume of the void **174**) substantially fully up to the perimeter edge **138** or to any other desired level. According to some embodiments, the void **174** has sloped side walls that taper outwardly in a direction from the bottom wall **130** to the opening **130**A.

According to some embodiments, the void **174** is shaped to conform to the upper half of the connector **200**. However, the void **174** may be of any other suitable shape. The void **174** includes a main section **174**A proximate the opening **130**A, and also a supplemental section **174**B on a side of the main section **174**A opposite the opening **130**A. In some embodiments, the supplemental section **174**B is located in the **125**A cavity.

The sealants **160**, **170** may be any suitable sealants. According to some embodiments, the sealants **160**, **170** are gel sealants. As used herein, "gel" refers to the category of materials which are solids extended by a fluid extender. The gel may be a substantially dilute system that exhibits no steady state flow. As discussed in Ferry, "Viscoelastic Properties of Polymers," 3rd ed. P. 529 (J. Wiley & Sons, New York 1980), a polymer gel may be a cross-linked solution whether linked by chemical bonds or crystallites or some other kind of junction. The absence of the steady state flow may be considered to be the definition of the solid-like properties while the substantial dilution may be necessary to give the relatively low modulus of gels. The solid nature may be achieved by a continuous network structure formed in the material generally through crosslinking the polymer chains through some kind of junction or the creation of domains of associated substituents of various branch chains of the polymer. The crosslinking can be either physical or chemical as long as the crosslink sites may be sustained at the use conditions of the gel.

Gels for use in this invention may be silicone (organopolysiloxane) gels, such as the fluid-extended systems taught in U.S. Pat. No. 4,634,207 to Debbaut (hereinafter "Debbaut '207"); U.S. Pat. No. 4,680,233 to Camin et al.; U.S. Pat. No. 4,777,063 to Dubrow et al.; and U.S. Pat. No. 5,079,300 to Dubrow et al. (hereinafter "Dubrow '300"), the disclosures of each of which are hereby incorporated herein by reference. These fluid-extended silicone gels may be created with nonreactive fluid extenders as in the previously recited patents or with an excess of a reactive liquid, e.g., a vinyl-rich silicone fluid, such that it acts like an extender, as exemplified by the Sylgard® 527 product commercially available from Dow-Corning of Midland, Mich. or as disclosed in U.S. Pat. No. 3,020,260 to Nelson. Because curing is generally involved in the preparation of these gels, they are sometimes referred to as thermosetting gels. The gel may be a silicone gel produced from a mixture of divinyl terminated polydimethylsiloxane, tetrakis (dimethylsiloxy)silane, a platinum divinyltetramethyldisiloxane complex, commercially available from United Chemical Technologies, Inc. of Bristol, Pa., polydimethylsiloxane, and 1,3,5,7-tetravinyltetra-methylcyclotetrasiloxane (reaction inhibitor for providing adequate pot life).

Other types of gels may be used, for example, polyurethane gels as taught in U.S. Pat. No. 4,600,261 to Debbaut (hereinafter "Debbaut '261") and U.S. Pat. No. 5,140,476 to Debbaut (hereinafter "Debbaut '476") and gels based on styrene-ethylene butylenestyrene (SEBS) or styrene-ethylene propylene-styrene (SEPS) extended with an extender oil of naphthenic or nonaromatic or low aramatic content hydrocarbon oil, as described in U.S. Pat. No. 4,369,284 to Chen; U.S. Pat. No. 4,716,183 to Gamarra et al.; and U.S. Pat. No. 4,942,270 to Gamarra. The SEBS and SEPS gels comprise glassy styrenic microphases interconnected by a fluid-extended elastomeric phase. The microphase-separated styrenic domains serve as the junction points in the systems. The SEBS and SEPS gels are examples of thermoplastic systems.

Another class of gels which may be used are EPDM rubber-based gels, as described in U.S. Pat. No. 5,177,143 to Chang et al.

Yet another class of gels which may be used are based on anhydride-containing polymers, as disclosed in WO 96/23007. These gels reportedly have good thermal resistance.

The gel may include a variety of additives, including stabilizers and antioxidants such as hindered phenols (e.g., Irganox™ 1076, commercially available from Ciba-Geigy Corp. of Tarrytown, N.Y.), phosphites (e.g., Irgafos™ 168, commercially available from Ciba-Geigy Corp. of Tarrytown, N.Y.), metal deactivators (e.g., Irganox™ D1024 from Ciba-Geigy Corp. of Tarrytown, N.Y.), and sulfides (e.g., Cyanox LTDP, commercially available from American Cyanamid Co. of Wayne, N.J., light stabilizers (e.g., Cyasorb UV-531, commercially available from American Cyanamid Co. of Wayne, N.J.), and flame retardants such as halogenated paraffins (e.g., Bromoklor 50, commercially available from Ferro Corp. of Hammond, Ind.) and/or phosphorous containing organic compounds (e.g., Fyrol PCF and Phosflex 390, both commercially available from Akzo Nobel Chemicals Inc. of Dobbs Ferry, N.Y.) and acid scavengers (e.g., DHT-4A, commercially available from Kyowa Chemical Industry Co. Ltd through Mitsui & Co. of Cleveland, Ohio, and hydrotalcite). Other suitable additives include colorants, biocides, tackifiers and the like described in "Additives for Plastics, Edition 1" published by D.A.T.A., Inc. and The International Plastics Selector, Inc., San Diego, Calif.

The hardness, stress relaxation, and tack may be measured using a Texture Technologies Texture Analyzer or like machine, having a load cell to measure force, a 5 gram trigger, and ¼ inch (6.35 mm) stainless steel probe. For measuring the hardness, for example, of a 20 mL glass vial containing 12 grams of gel, the probe is forced into the gel at the speed of 0.2 mm/sec to a penetration distance of 4.0 mm. The hardness of the gel is the force in grams required to force the probe at that speed to penetrate the gel specified for 4.0 mm. Higher numbers signify harder gels.

The tack and stress relaxation are read from the stress curve generated by tracing the force versus time curve experienced by the load cell when the penetration speed is 2.0 mm/second and the probe is forced into the gel a penetration distance of about 4.0 mm. The probe is held at 4.0 mm penetration for 1 minute and withdrawn at a speed of 2.00 mm/second. The stress relaxation is the ratio of the initial force (F_i) resisting the probe at the pre-set penetration depth minus the force resisting the probe (F_f) after 1 min divided by the initial force F_i, expressed as a percentage. That is, percent stress relaxation is equal to

$$1.\ \frac{(F_i - F_f)}{F_i} \times 100\%$$

where F_i and F_f are in grams. In other words, the stress relaxation is the ratio of the initial force minus the force after 1 minute over the initial force. It may be considered to be a measure of the ability of the gel to relax any induced compression placed on the gel. The tack may be considered to be the amount of force in grams resistance on the probe as it is pulled out of the gel when the probe is withdrawn at a speed of 2.0 mm/second from the preset penetration depth.

An alternative way to characterize the gels is by cone penetration parameters according to ASTM D-217 as proposed in Debbaut '261; Debbaut '207; Debbaut '746; and U.S. Pat. No. 5,357,057 to Debbaut et al., each of which is incorporated herein by reference in its entirety. Cone penetration ("CP") values may range from about 70 (10^{-1} mm) to about 400 (10^{-1} mm). Harder gels may generally have CP values from about 70 (10^{-1} mm) to about 70 (10^{-1} mm). Softer gels may generally have CP values from about 200 (10^{-1} mm) to about 400 (10^{-1} mm), with particularly preferred range of from about 250 (10^{-1} mm) to about 375 (10^{-1} mm). For a particular materials system, a relationship between CP and Voland gram hardness can be developed as proposed in U.S. Pat. No. 4,852,646 to Dittmer et al.

According to some embodiments, the gel has a Voland hardness, as measured by a texture analyzer, of between about 5 and 100 grams force. The gel may have an elongation, as measured by ASTM D-638, of at least 55%. According to some embodiments, the elongation is of at least 100%. The gel may have a stress relaxation of less than 80%. The gel may have a tack greater than about 1 gram.

While, in accordance with some embodiments, the sealants **160**, **170** are gels as described above, other types of sealants may be employed. For example, the sealants **160**, **170** may be silicone grease or hydrocarbon-based grease.

The enclosure assembly **100** may be formed in the following manner. The cover members **122**, **124** and the hinge **126** may be integrally formed. According to some embodiments, the cover members **122**, **124** and the hinge **126** are unitarily molded. According to some embodiments, the entirety of the housing **120** is unitarily molded. The housing **120** may be injection molded or vacuum formed, for example. According to other embodiments (e.g., if the cover members are not hinged), the cover members **122**, **124** are separately molded or otherwise formed. According to some embodiments, the cover members **122**, **124** and the hinge **126** are monolithic.

If the sealant **160**, **170** is a material, such as a curable gel, that requires curing, the sealant may be cured in situ. According to some embodiments, and with reference to FIGS. **7**, **8**, **18** and **19**, the sealants **160**, **170** may be formed as follows. Spacer inserts **8** and **9** having the shape and size of the voids **164** and **174**, respectively, are placed in each the cavities **136** of the cover member **122** and the cover member **124**, respectively. The spacer inserts **8**, **9** may be provided as separate parts (as shown in FIG. **18**) or a unitary part **7** as show in FIG. **19**. The housing **120** is oriented so that the cavities **136** are open upwardly. Each cover member **122**, **124** may be supported by a holder or base **11** (FIG. **18**). Liquid, uncured sealant is dispensed into the cavities **136** such that it fills the cavities **136** of the cover members **122**, **124** up to the desired level. The sealant may then be cured in situ. The spacer inserts **8**, **9** may be held in place using clips, a jig or the like to properly register the spacer inserts with the cover members **122**, **124** and to prevent the spacer inserts **8**, **9** from floating out of the liquid sealant. The spacer inserts **8**, **9** are then removed to provide the voids **164**, **174** in the sealants **160**, **170**. The liquid, uncured sealant may instead be inserted first and then displaced by insertion of the spacer inserts **8**, **9** prior to curing the uncured sealant. As will be apparent to those skilled in the art from the description herein, sealant-filled enclosures of the present invention may be formed by other methods. For example, a pre-cured sealant may be introduced into the cavities **136** (e.g., around the spacer inserts **8**, **9**).

The connector system **20** can be used as follows in accordance with methods of the present invention to form the enclosed connection **24**. Generally, the connection **22** is first formed by installing the connector **200** on the cables **12**, **14**. Thereafter, the enclosure assembly **100** is installed over the connection **22** and portions of the cables **12**, **14**.

The connector **200** can be used as follows in accordance with methods of the present invention to form the connection **22**.

If necessary, the compression mechanism **270** is loosened or opened to permit the jaw portions **224**, **234** and **225**, **235** (and thereby the blade members **252**, **254**) to be separated. The cable **12** (with the insulation layer **12**B covering the conductor **12**A) is inserted in or between the cable grooves **224**A, **234**A and the cable **14** (with the insulation layer **14**B covering the conductor **14**A) is inserted in or between the cable grooves **225**A, **235**A. The cables **12**, **14** can be axially or laterally inserted into the slots defined between the jaws.

The nut **276** is then driven to compress the compression mechanism **270** along the slide axis B-B and thereby drive the jaws **224**, **234** and **225**, **235** together along a clamping axis parallel to the slide axis B-B. The nut **276** is driven until a prescribed torque is applied. The shear nut **276** is driven via the shear head **276**A until a prescribed torque is applied, whereupon the shear head **276**A will break off at the shear section **276**C, thereby helping to ensure that the proper load is applied to the blade members **252**, **254**, **256**.

As a result, the insulation piercing features **252**B, **254**B of the opposed pairs of the blade members **252**, **254** are driven to converge on and capture the cables **12**, **14** therebetween. More particularly, the teeth **252**C, **254**C of each blade member **252**, **254** are forced through the insulation layer **12**B and into mechanical and electrical contact with the conductors **12**A, **14**A. The teeth **252**C, **254**C embed in the insulation layers **12**B, **14**B and make electrical and mechanical contact or engagement with the conductors **12**A, **12**B. In the foregoing manner, the connector **200** is operatively connected to the cables **12**, **14** and the conductors **12**A, **14**A are electrically connected to one another without stripping the insulation layers **12**B, **14**B.

According to some embodiments, the teeth **252**C, **254**C embed in the conductors **12**A, **14**A. According to some embodiments, the teeth **252**C, **254**C embed into the conductors **12**A, **14**A a distance of at least about 0.5 mm.

In the foregoing manner, the connection **22** is formed. The blade members **252**, **254** provide electrical continuity (i.e., a path for electrical current flow) between the conductors **12**A, **14**A of the cables **12**, **14**. The connector **200** mechanically secures the cables **12**, **14** relative to one another.

Once the connection **22** has been constructed as described above, the enclosure assembly **100** is installed on the connection **22** and the cables **12**, **14**. The enclosure assembly **100** may be held in a fully or partially open position as shown in FIG. **1** and the connection **22** may be inserted between the cover members **122**, **124**. The enclosure assembly **100** is then closed by urging one or both of the cover members **122**, **124** to relatively pivot about the hinge **126** into engagement as shown in FIG. **3**, such that the latch structures **181**A-**186**A and latch openings **181**B-**186**B are made to interlock in the closed position. The closed housing **120** defines an enclosure cavity **106** including a main enclosure cavity **107** and contiguous port channels **109** (collectively defined by the port extensions **140**). The connector **200** is received in the voids **164**, **174** of the sealants **160**, **170**. The connection **22** is encapsulated within the sealant **160**, **170**, and the sealant **160**, **170** and the connection **22** are in turn encapsulated within the housing **120** (i.e., contained within the enclosure cavity **106**). The portions of the cables **12**, **14** within the connection **22** and extending from the connection **22** and through the port channels **109** to the frangible walls **142** are likewise encapsulated in the sealant **160**, **170**.

The connection **22** is oriented relative to the cover member **122**, **124** such that the lower portion **200**A of the connector **200** is received and seats in the void **164**, and the upper portion **200**B of the connector **200** is received and seats in the main section **174**A of the void **174**. The upstanding portion **280**C of the clamping mechanism **270** (e.g., the projecting portion of the bolt **272** and the nut **276**) are received in the supplemental section **174**B of the void **174**.

According to some embodiments, the connection **22** is first placed in the cover member **122** of the enclosure assembly **100** (as shown in FIG. **1**). More particularly, the connector **200** may be placed or seated in the pre-defined void **164** such that the connector **200** may be partially encapsulated in the sealant **160**. The cover **124** is then closed on the cover **122** so that the exposed portion of the connector **200** is received in the pre-defined void **174** and so that this portion of the connector **200** is encapsulated in the sealant **170**. It will be appreciated that the order may be reversed so that the connector **200** is instead first placed in the cover member **124** before closing the enclosure assembly **100**.

Prior to or as the enclosure assembly **100** is closed, the cables **12**, **14** may break or splay the frangible walls **142** so that the cables **12**, **14** pass therethrough and are generally surrounded thereby. The walls **142** may be angled outwardly so that they tend to be splayed outwardly by the cables **12**, **14**.

In some embodiments, one or both of the cables **12**, **14** has a terminal end that projects from the connector **200**. In this case, the projecting cable end may be covered with one of the electrically insulating (e.g., elastomeric) end caps **262** and the end cap **262** can be secured in place using one of the end cap retainers **264**. The enclosure **100** and sealants **160**, **170** will then form an environmental seal about the end cap **262** which may extend out of the housing **120** through a port **109**. In other embodiments and as shown, the end caps **262** are not used.

The configuration of the curved latch fingers **181**A-**186**A as described above assist in keeping the latch fingers **181**A-**186**A properly aligned with the openings **181**B-**186**B and the cover members **122**, **124** aligned with one another. Also, the different selected heights H**1**, H**2**, H**3** as discussed above cause the latch fingers **181**A-**186**A to enter (and, in some embodiments interlock with) their respective latch openings **181**B-**186**B at substantially the same time as the cover members **122**, **124** are closed. This also helps to maintain the latch fingers **181**A-**186**A in proper alignment with the openings **181**B-**186**B and the cover members **122**, **124** aligned with one another. In this way, the configuration of the latch fingers **181**A-**186**A can ease the installation procedure and reduce the risk of inadvertent damage to the cover assembly.

According to some embodiments and as illustrated, the volumes and configurations of the sealants **160**, **170** are selected to ensure that the connection **22** displaces at least one, and according to some embodiments, both of the sealants **160**, **170** when the enclosure assembly **100** is transitioned from the opened position to the closed position with the connection **22** disposed therein.

According to some embodiments, the combined volume of the connector **200**, the portions of the cables **12**, **14** in the enclosure cavity **106**, and the sealants **160**, **170** is greater than the volume of the enclosure cavity **106**.

According to some embodiments and as illustrated, the volume of the enclosure cavity **106** is greater than the combined volume of the sealants **160**, **170**, but the volume of the enclosure cavity **106** not filled with the sealants **160**, 170 is less than the volume of the connection 22 (i.e., the connector 200 and the portions of the cables 12, 14 in the enclosure cavity 106).

According to some embodiments, the combined volume of the voids 164, 174 is less than or equal to the volume of the connector 200. According to some embodiments, the sum of the volumes of the voids 164, 174 is in the range of from about 60 to 100 percent of the volume of the connector 200 and, according to some embodiments, in the range of from about 85 to 95 percent of the volume of the connector 200.

According to some embodiments, when the enclosure assembly 100 is installed as described herein, the closing of the cover members 122, 124 about the connection 22 forcibly displaces the sealants 160, 170 about the connector 200 such that the sealants 160, 170 flow around the connector 200 and, in some cases, into interstices within the connector 50. According to some embodiments, the sealants 160, 170 substantially fully encapsulate the connector 200 as illustrated in FIGS. 5 and 6. According to other embodiments, the sealants 160, 170 only partially surround the connector 200 (e.g., in the case where the voids 164, 174 extend to the bottom walls 130).

By configuring the voids 164, 174 to have a combined volume less than the volume of the connector 200, the enclosure assembly 100 may ensure that the housing 120 can be closed without requiring undue force, but nonetheless that the sealants 160, 170 are displaced and forced to flow about the connection 22 and also that the sealants 160, 170 sufficiently engage with one another at the interface between the cover members 122, 124.

The side walls 132, the end walls 134 and the port extensions 140 may have slopes that tend to cause each sealant 160, 170 to flow toward the top opening 138A of its respective cover member 122, 124 to promote flow of the sealant about the connection 22 and into engagement with the other sealant 160, 170.

According to some embodiments, the connector system 20 is configured such that at least 75 percent of the sealant 160, 170 is retained in the housing 120 when the housing 120 is closed about the connection 22. According to some embodiments, some of the sealant 160, 170 may be forced out of the enclosure cavity 106 (e.g., through the ports 109 and/or other opening(s)).

As will be appreciated from the description herein, the sealant 160, 170 engages portions of the cables 12, 14 to form seals thereabout. The sealant 160, 170 also forms a sealing block that surrounds the connector 200, thereby sealing the connector 200. Notably, in the illustrated enclosure assembly 100, the sealant masses 160, 170 connect with one another to encapsulate the connector 200 and cables 12, 14.

The enclosure assembly 100 may be sized and configured to accommodate and seal multiple or a range of sizes of connectors 200 and cables 12, 14.

In some embodiments, the cover 120 and the cover assembly 100 can accommodate a range of inclination angles of the axis G-G of the connector 200 when the cover assembly 100 is installed around the connector 200. The inclination angle of the axis G-G may vary depending on the combination of sites of conductors 12, 14 in the connector 200 within its use range.

The cover assembly 100 and the connector 200 are re-enterable and removable for system disconnects, service or maintenance. In some embodiments, the cover assembly 100 and connector 200 are intended to be replaced and not re-used.

The enclosure assembly 100 may provide a number of advantages. The enclosure assembly 100 may provide a reliable seal about the connection 22. This seal may prevent or inhibit the ingress of moisture that would otherwise cause corrosion of the connection 22.

The sealant 160, 170 can seal any of the ports 109 through which no conductor extends (i.e., unused ports). This permits the connector system 20 to accommodate and environmentally seal multiple different configurations, including: main and tap/feed conductors extending through ports on both sides of the cover 120; both main and tap/feed conductors terminated inside the cover 120 (so that two ports remain unoccupied by a conductor); either main or tap/feed conductor terminated in the cover 120 while the other extends through both sides of the cover 120. This capability can eliminate the need for a separate cable end seal, and can offer significant cost savings to each installation.

Moreover, the sealant 160, 170 provides environmental protection for the locations in the insulation layers 12B, 14B pierced by the blade members 252, 254, 256.

The sealant 160, 170, particularly gel sealant, may accommodate conductors of different sizes within a prescribed range. The interfacing sealant masses 160, 170 and the relationship between the connector or connection volume and the sealant volumes (and the void 164, 174 volumes, if provided) may ensure that a suitable seal is provided by and between the sealant masses for a broadened range of sizes connections 22 positioned in the enclosure assembly 100.

The ribs 148 increase the strength and structural rigidity of the bottom walls 130 to resist mechanical impacts. The ribs 148 also provide additional "tooth" surfaces to promote adhesion between the sealant 160, 170 (e.g., gel sealant) and the cover members 122, 124.

When the sealant 160, 170 is a gel, the cables 12, 14 and the housing 120 may apply a compressive force to the sealant 160, 170 as the assembly 100 is transitioned from the open position to the closed position. The gel may thereby be elongated and be generally deformed and substantially conform to the outer surfaces of the connector 50, the cables 12, 14 and to the inner surface of the housing 120. Some shearing of the gel may occur as well. At least some of the gel deformation may be elastic. The restoring force in the gel resulting from this elastic deformation generally causes the gel to operate as a spring exerting an outward force between the housing 120 and the connector 200 and the cables 12, 14. The compressive loading and restoring force are maintained by the closure of the cover members 122, 124.

Various properties of the gel as described above may ensure that the gel sealant 160, 170 maintains a reliable and long lasting seal between the housing 120 and the connector 50 and the cables 12, 14. The elastic memory of and the retained or restoring force in the elongated, elastically deformed gel generally cause the gel to bear against the mating surfaces of the connector 200, the cables 12, 14 and the interior surface of the housing 120. Also, the tack of the gel may provide adhesion between the gel and these surfaces. The gel, even though it is cold-applied, is generally able to flow about the connector 50, the cables 12, 14 and the housing 120 to accommodate their irregular geometries.

According to some embodiments, the sealant 160, 170 is a self-healing or self-amalgamating gel. This characteristic, combined with the aforementioned compressive force between the connector 200, cables 12, 14 and the housing 120, may allow the sealant 160, 170 to re-form into a continuous body if the gel is sheared by the insertion of the cables **12**, **14** into the enclosure assembly **100**. The gel may also re-form if the connector **200** and cables **12**, **14** are withdrawn from the gel.

The sealant **160**, **170**, particularly when formed of a gel as described herein, may provide a reliable moisture barrier for the cables **12**, **14** and the connector **200**, even when the enclosure assembly **100** is subjected to extreme temperatures and temperature changes. The housing **120** may be made from an abrasion resistant material that resists being punctured by the abrasive forces.

The gel sealant may also serve to prevent or inhibit corrosion of the connection **22** by depositing a layer of oil from the gel on the exposed surfaces of the connector **200** and conductor portions **12**A, **14**A in the enclosure cavity **106**. Even if the gel is removed from the connection **22**, the oil may remain to coat the connection surfaces as a barrier to moisture.

As will be appreciated from the description herein, enclosure assemblies according to the present invention may be provided as pre-formed and fully assembled units, with pre-cured gel or other sealant therein as described above, that may be cold applied about a connection to form a seal.

In some embodiments, the void forming inserts **8**, **9** are removed after the voids **164**, **174** are formed, and the cover assembly **100** is then packaged for delivery to the end user.

In other embodiments, the void forming inserts **8**, **9** are left in place in the sealant masses **160**, **170** after the voids **164**, **174** are formed. The inserts **8**, **9** are then removed by the end user prior to final installation. In this case, the inserts **8**, **9** can help maintain the shapes of the voids **164**, **170** and protect the sealants **160**, **170** from contamination during shipping and handling. The inserts **8**, **9** can eliminate the need for a secondary operation or component to serve these purposes.

While, in accordance with some embodiments, the housing **120** is integrally and unitarily formed, the housing may be otherwise formed in accordance with some aspects of invention. For example, the cover members **122**, **124** and/or the hinge **126** may be separate parts joined together in hinged fashion or otherwise. For example, the cover members **122**, **124** may be separate pieces secured together by tie wraps, snaps, latches or the like and/or not hinged.

According to some embodiments, the voids **164**, **174** are substantially centered with respect to the cavities **136**. According to some embodiments, the voids may instead be offset.

According to some embodiments, the voids **164**, **174** extend all the way to the bottom walls **130**.

According to some embodiments, an enclosure assembly **100** as described herein may be formed without the sealant voids **164**, **174** (i.e., the cover members **122**, **124** are solid filled up to a desired level). In this case, portions of the sealants **160**, **170** may be forced out of the enclosure cavity **106** (e.g., through the ports **109** and/or other openings). This modified enclosure assembly can be formed in the same manner as described above for the enclosure assembly **100** except that the aforementioned spacer inserts are omitted.

According to some embodiments, a housing as disclosed herein (e.g., the housing **120**) may be used to enclose a connection including an IPC connector (e.g., the connection **22**) without the provision of sealant (e.g., the sealants **160**, **170**) therein. Such a sealant-free housing may provide touch protection.

According to some embodiments, the enclosure assembly **100** and the connector **200** are pre-configured or packaged as a matched kit. However, the enclosure assembly **100** and the connector **200** need not be provided as a kit. For example, the enclosure assembly **100** may be retrofitted onto a connector **200** that has been previously installed, even years prior.

Connectors according to embodiments of the invention may employ more or fewer clamping mechanisms than shown for the exemplary embodiments. According to some embodiments, other types of clamping mechanisms may be employed.

The methods and connector assemblies in accordance with embodiments of the present invention may provide the advantages of relatively slow displacement tools (including battery-powered tools). As compared to at least some explosive actuated tools, the present methods and connector assemblies may provide improvements in simplicity, safety, speed, reduction in training requirements, environmental impact, ergonomics, and cost savings. Hand and battery operated tools may also be employed in countries, environments and applications where use of explosives is limited.

According to some embodiments, the cables **12**, **14** are power transmission conductors. According to some embodiments, the cables **12**, **14** are aerial power transmission conductors. According to some embodiments, the cable **12** is a main line electrical conductor cable and the cable **14** is a tap line electrical conductor cable.

In some embodiments, connector systems **20** as disclosed herein are used in a solar electrical power generation collection system **40** (FIG. **17**). The connector systems **20** are used to electrically connect a plurality of distributed solar electrical generation devices **42** to a central collection point. Each solar device **42** may include an array of solar energy cells (a solar array). In some embodiments, the solar energy cells are photovoltaic cells. Each solar array **42** may take the form of a panel (solar panel).

Each solar array (e.g., photovoltaic panel) includes a feed cable **44**. One end of the feed cable **44** may be connected to a first one of the solar arrays **42** while the other end of the feed cable **44** is connected to a second one of the solar arrays **42**. A main cable **46** (which may be referred to as a collector or trunk cable) is connected to the central collection point (e.g., a combiner box) directly or through a further conductor (e.g., a main trunk cable **48**). The main cable **46** is electrically connected to the feed cable **44** by the connector **200** so that current from the two solar arrays **42** is directed into the main cable **46**. The connector **200** is housed in a cover assembly **100** to form a protected connection assembly **24** as described herein.

Alternatively, each solar array **42** may have an individual feed cable **44** that is received into the cover assembly **100** through a respective one of the ports **109** and terminated at the connector **200**.

The solar electrical power generation collection system **40** may include a plurality of the connections **24**. The main cable **46** may be connected to one or more feed cables **44** in each connection **24**.

According to some embodiments, the protected connection assembly **24** is compliant with Underwriters Laboratory Standard UL6703 (Edition date 2011 Aug. 2). According to some embodiments, the protected connection assembly **24** can be buried directly underground (without provision of an additional enclosure) in compliance with Underwriters Laboratory Standard UL486D (Edition date 2015 Jun. 19).

According to some embodiments, the conductors **12**, **14** have a diameter of from about 0.222 to 1 inch.

In some embodiments, one or more of the slots **181**B-**186**B and the slots at the bases of the prongs **181**A-**186**A can receive cable ties, which can be used to secure the cover assembly **100** in the closed position. Additionally, other cable tie slots may be formed in the cover **120** to receive cable ties.

With reference to FIGS. **20-27**, a sealant-filled enclosure assembly **300** according to further embodiments of the present invention is shown therein. The enclosure assembly **300** may be used in place of the enclosure assembly **100** and with the connector **200** (not visible in FIGS. **20-27**) to form a connector system **20'**. The connector system **20'** may be used to form an enclosed and protected connection assembly **24'** in the same manner as described above for forming the connection assembly **24** using the connector system **20**, except as discussed below. The protected connection assembly **24'** can be used in an electrical power transmission such as the system **40** (FIG. **17**), for example.

The sealant-filled enclosure **300** includes a housing **320** and masses of sealant **360**, **370** disposed therein. According to some embodiments, and as discussed above with regard to the sealant **160**, **170**, the sealant **360**, **370** may be a gel. The housing **320** includes a first shell or cover member **322** and a second shell or cover member **324** joined to one another by a hinge **326** and adapted to move between an open position as shown in FIG. **20** and a closed position as shown in FIG. **25**. In the open position, the enclosure assembly **300** can receive the connection **22** (FIG. **1**) and adjacent portions of the cables **12**, **14**. In the closed position, the enclosure assembly **300**, including the masses of sealant **360**, **370**, may operate to seal about and protect the connection **22**. In the closed position, the enclosure assembly **100** defines an enclosure cavity corresponding to the enclosure cavity **106** (FIG. **10**) and opposed pairs of ports **309** (FIGS. **25** and **26**) communicating with the enclosure cavity **306**. The shape or geometry of the enclosure cavity resembles or substantially conforms that of the connector **200**.

Each cover member **322**, **324** includes a bottom wall **330**. Opposed side walls **332** and opposed end walls **334** extend upwardly from the bottom wall **330**. Opposed pairs of port extensions **340** extend longitudinally from either end of each cover member **322**, **324**. Each port extension **340** is terminated by a port wall **342**. The port walls **342** may be constructed as described above for the port walls **142**.

The upper edges of the walls **332**, **334** form a perimeter edge **338** defining an opening. The walls **330**, **332**, **334** and the port extensions **340** of each cover member **322**, **324** define an overall cover member chamber or cavity and a front opening **330**A communicating with the cavity. The cover member cavity includes a main cavity portion **336**A and conductor port subchannels **336**B defined within each port extension **340**.

The cover member **324** further includes a dome **325** defined in its bottom wall **330**. The dome **325** defines an extension cavity **325**A. The extension cavity **325**A is contiguous with and communicates with the main cavity **336**A of the cover member **324**.

The cover members **322**, **324** are pivotably joined by the hinge **326**. According to some embodiments, the hinge **326** is a flexible, living hinge.

The housing **320** includes a latch system including four integral latch mechanisms. Each latch mechanism includes a latch finger **382** on and projecting inwardly from the cover member **324**. Each latch mechanism further includes a latch slot or opening **383** in the cover member **322**. The latch fingers **382** may be integrally formed with the cover member **324**. The latch fingers **382** and openings **383** can be selectively engaged, whereupon they cooperate to releasably secure the cover members **322**, **324** in a closed configuration as shown in FIGS. **25-27**. Each latch finger **382** has elastically deflectable legs **382**A (FIG. **26**) and an integral interlock section or barb **382**B. The barb **382**B is configured to enter through the associated opening **383** and interlock with the cover member **324** as shown in FIGS. **25-27**.

The housing **320** further includes a safety latch mechanism **384**. The safety latch mechanism **384** includes two side-by-side safety latch members **385** located on the end of the cover member **324** opposite the hinge **326**. Each latch member **385** is pivotably connected to the cover member **324** by a hinge **385**A (e.g., a living hinge). The safety latch mechanism **384** also includes an interlock feature in the form of a widthwise extending latch flange **389**.

Each latch member **385** includes a body **385**B and a pair of latch fingers **386**. Each latch finger **386** is connected to the body **385**B by a base **388**. In some embodiments, each base **388** is configured such that the latch finger **386** is substantially rigid and nondeflectable relative to the body **385**B.

Each latch finger **386** further includes an integral interlock section or barb **387**. Each barb **387** has a tapered or ramped cam surface **387**A (FIG. **27**).

Each cover member **322**, **324** includes a pair of opposed strain relief features or frame portions **350** extending longitudinally and laterally outboard from the port walls **342** on either side. The frame portions **350** collectively form a cable strain relief system **351**.

Each frame portion **350** includes a longitudinally extending strain relief wall **352** and a central leg **354** and outer legs **354**D connecting the wall **352** to the adjacent side wall **332**. The walls **352** are rigidly affixed to the side walls **332** by the legs **354**, **354**D.

Each wall **352** includes a pair of strain relief channels or slots **352**A defined therein. When the cover members **322**, **324** are closed (as shown in FIG. **25**), the pairs of opposing slots **352**A combine to form strain relief openings **352**B. Each strain relief opening **352**B is aligned with a respective one of the ports **309**.

In some embodiments, the distance D**15** (FIG. **23**) from each frangible port wall **342** to the outer end of the adjacent strain relief opening **352**B is in the range of from about 0.5 inch to 0.875 inch.

Each wall **352** is spaced away from the adjacent side wall **332** so that voids or openings **354**B are defined between each port wall **342** and its adjacent slot **352**A. Likewise, the openings **354**B separate each port **309** from its associated strain relief opening **352**B. In some embodiments, each wall **352** is spaced away from the adjacent port wall **342** a standoff distance D**14** (FIG. **23**) in the range of from about 0.2 inch to 0.4 inch.

The legs **354** of the cover member **322** each include a pair of upstanding tabs defining a slot **354**A therebetween. Each slot **354**A is configured and positioned to receive the opposing leg **354** of the cover member **324** when the cover **320** is closed.

Prior to use, the sealant **360** is contained in the cavity **336** of the cover member **322** such that a main sealant portion of the sealant **360** is disposed in the main cavity **336**A and port sealant portions of the sealant **360** are disposed in the port subchannels **336**B.

According to some embodiments, a void **364** (FIG. **21**) is pre-formed or defined in the sealant **360**. According to some embodiments, the void **364** is open to the opening **330**A. According to some embodiments, the sealant **360** fully surrounds the remainder of the void **364** so that the void **364** is spaced apart from cover member **322** (by the sealant **360**) on all sides except the top side. According to some embodiments, the sealant **360** fills the cover member cavity **336** (not including the volume of the void **364**) to a level near but not fully to the perimeter edge **338**. In other embodiments and as shown in FIGS. **20** and **21**, the sealant **360** fills the cover member cavity **336** of the cover member **322** substantially fully up to the perimeter edge **338**.

Prior to use, the sealant **370** may be contained in the cavity **336** of the cover member **324** such that a main sealant portion of the sealant **370** is disposed in the main cavity **336** and port sealant portions are disposed in the port subchannels **336**B.

According to some embodiments, a void **374** is preformed or defined in the sealant **370**. According to some embodiments, the void **374** is open to the opening **330**A. According to some embodiments, the sealant **370** fully surrounds the remainder of the void **374** so that the void **374** is spaced apart from cover member **324** on all sides except the top side. According to some embodiments, the sealant **370** fills the cavity **336** of the cover member **124** to a level near but not fully to the perimeter edge **138**. In other embodiments and as shown in FIGS. **20** and **21**, the sealant **370** fills the cover member cavity **336** (not including the volume of the void **374**) substantially fully up to the perimeter edge **338**.

According to some embodiments, the voids **364**, **374** are shaped to conform to respective lower and upper halves of the connector **200**, as discussed above with regard to the voids **164**, **174**.

The cover member **324** further includes two opposed, integral, upstanding sealant retention flanges **337**A. Each flange **337**A is positioned along an end edge of the perimeter **338** (i.e., at the edge of the opening **330**A) and extends across the width of the cover member **324**. As shown in FIG. **21**, each flange **337**A projects a height H**10** above the top surface **370**A of the sealant **370**.

The cover member **322** further includes two opposed, integral, recessed sealant retention troughs or grooves **337**B. Each groove **337**B is positioned along an end edge of the perimeter **338** (i.e., at the edge of the opening **330**A) and extends across the width of the cover member **322**. As shown in FIG. **21**, each groove **337**B is recessed a depth H**11** below the top surface **360**A of the sealant **360**.

The cover member **324** further includes two opposed, integral, raised lands **339**A. Each land **339**A is positioned between the port extensions **340** on a side of the cover member **324**. As shown in FIG. **21**, each land **339**A projects a height H**12** (FIG. **21**) above the top surface **370**A of the sealant **370**.

The cover member **322** further includes two opposed, integral, recessed lands **339**B. Each land **339**B is positioned between the port extensions **340** on a side of the cover member **322**. As shown in FIGS. **21** and **22**, each land **339**B is recessed a depth H**13** (FIG. **21**) below the top surface **360**A of the sealant **360**.

The enclosure assembly **300** may be formed as described above for the enclosure assembly **100**. The cover members **322**, **324** and the hinges **326**, **385**A may be integrally formed. According to some embodiments, the cover members **322**, **324** and the hinges **326**, **385**A are unitarily molded. According to some embodiments, the entirety of the housing **320** is unitarily molded. The housing **320** may be injection molded or vacuum formed, for example. According to some embodiments, the cover members **322**, **324** and the hinges **326**, **385**A are monolithic.

The sealants **360**, **370** may be installed in the cover members **122**, **124**, and the voids may be formed, as s described above for the enclosure assembly **100**.

The enclosure assembly **300** may be formed using the same material as described above for the enclosure assembly **100**.

The connector system **20'** can be used as follows in accordance with methods of the present invention to form the enclosed connection **24'**. Generally, the connection **22** is first formed by installing the connector **200** on the cables **12**, **14** as described above. Thereafter, the enclosure assembly **300** is installed over the connection **22** and portions of the cables **12**, **14**.

In order to install the enclosure assembly **300** on the connection **22** and the cables **12**, **14**, the enclosure assembly **300** may be held in a fully or partially open position as shown in FIG. **20**. The safety latch members **385** are in an open or ready position. The connection **22** is then inserted between the cover members **322**, **324**. The enclosure assembly **300** is then closed by urging one or both of the cover members **322**, **324** to relatively pivot about the hinge **326** into engagement as shown in FIG. **24**, such that the latch fingers **382** and latch openings **383** are made to interlock in the closed position.

With cover members **322**, **324** fully closed or nearly fully closed, the safety latch members **385** are pivoted in a direction FP (FIG. **27**) about the hinges **385**A until the barbs **387** of their latch fingers **386** interlock with the latch flange **389**, as shown in FIGS. **25** and **26**. Each safety latch member **385** is thereby placed in its safety latching position. The interlocks between the latch features **382**, **383** are thereby reinforced by the safety latch members **385**. The main latch features **382**, **383** proximate the free ends of the cover members **322**, **324** and the safety latch mechanism provide a double interlock securement.

In some instances, the latch members **385** may be folded direction FP as described while the cover members **322**, **324** are not fully mated and closed and, in some cases, when the latch fingers **382** are not fully interlocked with their latch openings **383**. In this case, the force applied to the latch members **385** serves to force or pinch the cover members **322**, **324** together toward closure. More particularly, the ramped surfaces **387**A of the barbs **387** operate as a cam surface that applies compressive loading in opposed directions FC (FIG. **27**). The ramped surfaces **387**A convert the longitudinally inwardly directed force applied by the installer to the latch member **385** into a transversely directed closure force.

When the cover **320** is closed, the engagements between the slots **354**A of the cover member **322** and the legs **354** of the cover member **324** reinforce the rigidity of the cover **320**. The interaction between these features may also facilitate and maintain proper alignment between the cover members **322**, **324** as they are transitioning into the closed position.

The closed housing **320** defines an enclosure cavity **306** including a main enclosure cavity **307** and contiguous port channels **309** (collectively defined by the port extensions **340**). The connector **200** is received in the voids **364**, **374** of the sealants **360**, **370**. The connection **22** is encapsulated within the sealant **360**, **370**, and the sealant **360**, **370** and the connection **22** are in turn encapsulated within the housing **320**. The portions of the cables **12**, **14** within the connection **22** and extending from the connection **22** and through the port channels **309** to the frangible walls **342** are likewise encapsulated in the sealant **360**, **370**.

The environmental seal is further enhanced by the sealant retention flanges **337**A and the sealant retention grooves **337**B. As the cover **320** is closed, the flanges **337**A will travel into the grooves **337**B and embed in the sealant **360** contained therein, as shown in FIG. **26**. The features **337**A, **337**B thereby serve to better contain the sealants **360**, **370** and form a seal at the interface between the cavities of the cover members **322**, **324**.

The environmental seal is also further enhanced by the lands **339**A, **339**B. As the cover **320** is closed, the raised lands **339**A will travel into the recesses over the recessed lands **339**B and embed in the sealant **360** contained therein, as shown in FIG. **26**.

The strain relief system **350** provides strain relief for the cables **12**, **14** where they exit the enclosure **300**. In some embodiments, the openings **352**B are sized with a diameter slightly larger (e.g., from about 0 to 0.1 inch larger) than the outer diameter of the largest diameter cable for which the enclosure **300** is designed/sized. In use, the openings **352**B and brace walls **352** limit lateral displacement (e.g., bending, twisting, translating, shifting) of the cables **12** in the openings. This can help to attenuate forces applied to the connection via the cables **12**, **14** and prevent movement of the cables **12**, **14** from distorting the cover housing **320** and/or the sealant **360**, **370**. Such distortion may degrade the environmental seal of the enclosed connection **24'**.

The strain relief system **350** also imparts additional rigidity to the enclosure assembly **300**. This improved strength can enhance the performance of the enclosure both during installation and in service.

The housing **320** may also include supplemental openings **355** in the covers **322**, **324**. The openings **355** may be used to receive zip ties to secure the enclosure **300** closed and/or to receive a rod or other device for suspending the enclosure **300**.

Enclosure assemblies as disclosed herein and/or features thereof may be used with other types of electrical connectors in place of the connector **200**.

It will be appreciated that enclosures in accordance with the present invention may have components (e.g., cover members, walls, etc.) and cavities or chambers having shapes, configurations and/or sizes different than those shown and described herein.

The foregoing is illustrative of the present invention and is not to be construed as limiting thereof. Although a few exemplary embodiments of this invention have been described, those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments without materially departing from the novel teachings and advantages of this invention. Accordingly, all such modifications are intended to be included within the scope of this invention. Therefore, it is to be understood that the foregoing is illustrative of the present invention and is not to be construed as limited to the specific embodiments disclosed, and that modifications to the disclosed embodiments, as well as other embodiments, are intended to be included within the scope of the invention.

That which is claimed is:

1. An enclosed connection system for mechanically and electrically connecting first and second cables each including an elongate electrical conductor covered by an insulation layer, the enclosed connection system comprising:

a) an insulation piercing connector including:

at least one electrically conductive piercing member; and

a clamping mechanism configured and operable to force the at least one piercing member through the insulation layers of the first and second cables and into electrical engagement with the conductors of the first and second cables to form a connection including the insulation piercing connector and the first and second cables wherein the conductors of the first and second cables are electrically connected to one another through the at least one piercing member; and

b) an enclosure configured to receive and cover the connection and to protect the insulation piercing connector;

wherein:

the enclosure includes first and second cover members defining first and second cover member cavities, respectively, and being pivotally connected by a hinge;

the first and second cover members are relatively pivotable about the hinge between an open position to receive the connection and a closed position wherein the first and second cover members define an enclosure cavity to contain the connection such that the insulation piercing connector is encapsulated in the first and second cover members; and

the enclosed connection system includes:

a main latch mechanism including:

a first latch feature forming a part of the first cover member; and

a second latch feature forming a part of the second cover member; and

a safety latch mechanism including:

a safety latch member pivotally connected to the first cover member by a second hinge, the safety latch member including a first safety latch feature; and

a second safety latch feature on the second cover member;

wherein:

the first and second latch features are configured to interlock with one another when the first and second members are placed in the closed position; and

the safety latch member is configured to pivot about the second hinge from a ready position to a safety latching position after the first and second cover members are placed in the closed position; and

in the safety latching position, the first and second safety latch features are interlocked with one another.

2. The enclosed connection system of claim **1** wherein the enclosure includes a flowable sealant disposed in at least one of the first and second cover members to provide a seal about the insulation piercing connector.

3. The enclosed connection system of claim **2** wherein the sealant is a gel.

4. The enclosed connection system of claim **2** wherein the enclosure includes a first flowable sealant disposed in the first cover member cavity and a second flowable sealant disposed in the second cover member cavity;

wherein the enclosure is configured such that the insulation piercing connector will displace the first and second sealants when the first and second cover members are moved from the open position to the closed position about the insulation piercing connector.

5. The enclosed connection system of claim **4** wherein the first and second sealants are first and second gels adapted to be elongated and elastically deformed in the closed position when the insulation piercing connector is disposed in the enclosure cavity.

6. The enclosed connection system of claim **4** wherein:

the insulation piercing connector has a connector volume;

the first and second sealants include first and second voids, respectively, defined therein to receive the insulation piercing connector, the first and second voids having a first void volume and a second void volume, respectively; and

the sum of the first void volume and the second void volume is less than the connector volume.

7. The enclosed connection system of claim **6** wherein the sum of the first void volume and the second void volume is between about 60 and 100 percent of the connector volume.

8. The enclosed connection system of claim **4** wherein:

the first cover member includes an integral sealant retention flange projecting above an upper surface of the first sealant;

the second cover member includes an integral sealant retention groove positioned below an upper surface of the second sealant and containing a portion of the second sealant; and

when the first and second cover members are moved from the open position to the closed position about the insulation piercing connector, the sealant retention flange will enter the sealant retention groove and embed in the second sealant in the sealant retention groove to form a seal at the interface between the first and second cavities.

9. The enclosed connection system of claim **4** wherein:

the first cover member includes:

a first port extension forming a part of the first cover member cavity;

a first strain relief slot; and

a first openable port wall located between the first port extension and the first strain relief slot;

the second cover member includes:

a second port extension forming a part of the second cover member cavity;

a second strain relief slot; and

a second openable port wall located between the first port extension and the first strain relief slot; and

when the first and second cover members are in the closed position:

the first and second port extensions combine to form a cable port;

the first and second strain relief slots combine to form a strain relief opening;

the first and second port walls partition the cable port from the strain relief opening;

the enclosure is configured to receive the first cable such that the first cable extends from the insulation piercing connector in the enclosure cavity, through the cable port, through the first and second port walls, and through the strain relief opening;

the first and second port walls inhibit flow of the first and second flowable sealants from the cable port toward the strain relief opening; and

the strain relief opening is configured to receive a portion of the first cable to provide strain relief for the first cable.

10. The enclosed connection assembly of claim **2** wherein at least one of the first and second cover members includes a plurality of integral ribs configured to enhance adhesion between the sealant and the cover member.

11. The enclosed connection system of claim **1** wherein the enclosure includes:

a conductor port configured to receive the first conductor therethrough; and

a frangible port wall extending across the conductor port.

12. The enclosed connection system of claim **1** wherein the enclosure cavity has a shape that substantially conforms to a shape of the insulation piercing connector.

13. The enclosed connection system of claim **1** wherein at least one of the first latch feature and the second latch feature includes a curved latch finger.

14. The enclosed connection system of claim **1** wherein the first safety latch feature includes a ramped cam surface that forces the first and second cover members together as the safety latch member is pivoted into the safety latching position.

15. A method for forming an enclosed connection assembly about first and second cables each including an elongate electrical conductor covered by an insulation layer, the method comprising:

a) providing an insulation piercing connector including:

at least one electrically conductive piercing member; and

a clamping mechanism configured and operable to force the at least one piercing member through the insulation layers of the first and second cables and into electrical engagement with the conductors of the first and second cables to form a connection including the insulation piercing connector and the first and second cables wherein the conductors of the first and second cables are electrically connected to one another through the at least one piercing member;

b) selectively operating the clamping mechanism of the insulation piercing connector to force the at least one piercing member through the insulation layers of the first and second cables and into electrical engagement with the conductors of the first and second cables such that the conductors of the first and second cables are electrically connected to one another through the at least one piercing member to thereby form a connection; and

c) covering the connection and protecting the insulation piercing connector with an enclosure;

wherein:

the enclosure includes first and second cover members defining first and second cover member cavities, respectively, and being pivotally connected by a hinge;

the first and second cover members are relatively pivotable about the hinge between an open position to receive the connection and a closed position wherein the first and second cover members define an enclosure cavity to contain the connection such that the insulation piercing connector is encapsulated in the first and second cover members;

the enclosed connection system includes:

a main latch mechanism including:

a first latch feature forming a part of the first cover member; and

a second latch feature forming a part of the second cover member; and

a safety latch mechanism including:

a safety latch member pivotally connected to the first cover member by a second hinge, the safety latch member including a first safety latch feature; and

a second safety latch feature on the second cover member;

wherein:

the first and second latch features are configured to interlock with one another when the first and second members are placed in the closed position;

the safety latch member is configured to pivot about the second hinge from a ready position to a safety latching position after the first and second cover members are placed in the closed position; and

in the safety latching position, the first and second safety latch features are interlocked with one another; and

covering the connection and protecting the insulation piercing connector with the enclosure includes:

placing the first and second members in the closed position about the insulation piercing connector; and thereafter,

placing the safety latch member in the safety latching mechanism.

16. A solar electrical power generation collection system comprising:

a plurality of distributed solar electrical generation devices;

a plurality of feed cables each extending from a respective one of the solar electrical generation devices;

a trunk cable; and

a plurality of enclosed connection systems each mechanically and electrically connecting a respective one of the feed cables to the trunk cable, each enclosed connection system including:

a) an insulation piercing connector including:

at least one electrically conductive piercing member; and

a clamping mechanism configured and operable to force the at least one piercing member through the insulation layers of the feed and trunk cables and into electrical engagement with the conductors of the feed and trunk cables such that the conductors of the feed and trunk cables are electrically connected to one another through the at least one piercing member; and

b) an enclosure configured to receive and cover the connection and to protect the insulation piercing connector;

wherein:

the enclosure includes first and second cover members defining first and second cover member cavities, respectively, and being pivotally connected by a hinge;

the first and second cover members are relatively pivotable about the hinge between an open position to receive the connection and a closed position wherein the first and second cover members define an enclosure cavity to contain the connection such that the insulation piercing connector is encapsulated in the first and second cover members; and

the enclosed connection system includes:

a main latch mechanism including:

a first latch feature forming a part of the first cover member; and

a second latch feature forming a part of the second cover member; and

a safety latch mechanism including:

a safety latch member pivotally connected to the first cover member by a second hinge, the safety latch member including a first safety latch feature; and

a second safety latch feature on the second cover member;

wherein:

the first and second latch features are configured to interlock with one another when the first and second members are placed in the closed position; and

the safety latch member is configured to pivot about the second hinge from a ready position to a safety latching position after the first and second cover members are placed in the closed position; and

in the safety latching position, the first and second safety latch features are interlocked with one another.

17. The solar electrical power generation collection system of claim **16** wherein the enclosure includes a flowable sealant disposed in at least one of the first and second cover members to provide a seal about the insulation piercing connector.

18. The solar electrical power generation collection system of claim **16** wherein at least one of the first latch feature and the second latch feature includes a curved latch finger.

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